An Assessment of the Commercial Fishery and Population Structure of Walleye in Kakisa Lake, Northwest Territories, 1977-1985

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ABSTRACT

Roberge, M.M., G. Low, and C.J. Read. 1986. An assessment of the commercial fishery and population structure of walleye in Kakisa Lake, Northwest Territories, 1977-1985. Can. Tech. Rep. Fish. Aquat. Sci. 1435: v + 59 p.

Biological samples have been taken from the commercial walleye fishery from Kakisa Lake, Northwest Territories (NWT) since 1977 (excluding 1978). Together with information collected from an experimental gillnetting program in 1978, the status of the walleye stock is assessed and a management strategy is formulated.

Variations in fishing effort since 1946 is likely the cause of fluctuations in the commercial production of walleye. Factors resulting in changes in mean length and age from year to year of the commercial samples, since 1977, include timing and location of fishing effort and variability in year class strength. Fluctuations in instantaneous total mortality are considered to be due to changes in fishing mortality. The impact on these changes by the domestic fishery is unknown. Growth rates from year to year are not significantly different. Recruitment overfishing is not believed to have occurred. The minimum mesh size of 108 mm, in use since 1981, appears to be protecting a large fraction of the pre-recruitment segment of the population.

Despite continued commercial exploitation, walleye still remains the dominant species in Kakisa Lake. The size and age of walleye have decreased since 1946, resulting from the initial fishing down of the larger, older fish in the population. Growth rates have not altered significantly from 1968 to 1978 while age-at-maturity has not decreased since 1946.

Application of the Beverton and Holt yield-per-recruit model verified that Kakisa Lake walleye were not being over-exploited by the commercial fishery. Optimum fishing mortality ($F_{0.1}$) from 1977 to 1985 ranged from 0.40 to 0.55. Estimates of total allowable catch (annual) during this period using the Baranov catch equation ranged from 11 734 kg to 31 904 kg. Considering the history of the fishery, the annual commercial quota should not exceed 20 000 kg.

Key words: Baranov catch equation; Beverton and Holt yield-per-recruit; catch curve; catch statistics; experimental gillnetting; fishing mortality; Stizostedion vitreum; stock assessment.

RÉSUMÉ

Roberge, M.M., G. Low, and C.J. Read. 1986. An assessment of the commercial fishery and population structure of walleye in Kakisa Lake, Northwest Territories, 1977-1985. Can. Tech. Rep. Fish. Aquat. Sci. 1435: v + 59 p.

Des prélèvements biologiques sont faits dans la pêcherie commerciale au doré du lac Kakisa depuis 1977 (sauf en 1978); ces données, ainsi que celles recueillies dans le cadre d'un programme de pêche expérimentale au filet maillant mené en 1978, ont servi à faire une évaluation du stock de doré et à formuler une stratégie de gestion.

Les fluctuations des quantités de dorés capturés dans cette pêche commerciale sont vraisemblablement imputables aux variations de l'effort de pêche depuis 1946. Parmi les facteurs qui entraînent des variations d'une année à l'autre depuis 1977 de la longueur moyenne et de l'âge des échantillons prélevés dans les prises commerciales, il y a le moment et l'endroit où s'exerce l'effort de pêche ainsi que la variabilité de l'abondance de chaque classe d'âge. On estime que les fluctuations de la mortalité totale instantanée sont attribuables à des changements dans la mortalité due à la pêche; les répercussions attribuables à la pêche de subsistance ne sont pas connues. Les taux de croissance d'une année à l'autre ne présentent pas de différences importantes. On ne croit pas qu'il y ait eu surexploitation des recrues; la grandeur de maille minimale, en vigueur depuis 1981, est de 108 mm et il semble qu'elle contribue à protéger une grande partie des pré-recrues dans la population.

En dépit de l'exploitation commerciale ininterrompue, le doré n'en reste pas moins l'espèce dominante dans le lac Kakisa. La taille et l'âge du doré ont diminué depuis 1946, en raison de la perte des sujets plus gros et plus âgés de la population, capturés au départ. Les taux de croissance n'ont pas varié de façon significative entre 1968 et 1978 tandis que l'âge à la maturité n'a pas diminué depuis 1946.

L'application du modèle de rendement par recrue de Beverton et Holt a permis d'établir que la pêche commerciale n'entraîne aucune surexploitation du doré du lac Kakisa. La mortalité optimale due à la pêche ($F_{0.1}$) de 1977 à 1985 variait de 0,40 à 0,55. Les estimations du total (annuel) des prises admissibles au cours de la même période, obtenues à l'aide de l'équation de Baranov, variaient entre 11 734 et 31 904 kg. Compte tenu des antécédents de cette pêcherie, le contingent annuel de pêche commerciale ne devrait pas dépasser 20 000 kg.

Mots-clés: équation de Baranov; modèl de rendement par recrue de Beverton et Holt; courbe des prises; pêche expérimentale au filet maillant; statistiques des prises; mortalité due à la pêche; Stizostedion vitreum; évaluation des stocks.

INTRODUCTION

The walleye, Stizostedion vitreum (Mitchill), occurs in Canada from central Quebec through Ontario, the Prairie Provinces, northeastern British Columbia and north into the Northwest Territories (NWT) and is considered to be the most economically valuable fish species in Canadian inland waters (Scott and Crossman 1973). In the NWT, walleye (commonly referred to as pickerel) are confined to the Mackenzie River drainage reaching their northern limit in the Mackenzie Delta (Scott and Crossman 1973). Although the distribution of walleye in the NWT is limited, it is considered to be an important commercial and sport fish species.

Information on the biology and harvest of walleye in the NWT is meager in comparison to that for walleye from other areas of Canada. Miller (1947), Rawson (1947, 1951) and Johnson (1975) provide general information on walleye from Great Bear and Great Slave lakes. Falk and Dahlke (1975), Falk et al. (1980) and Bond et al. (1978) describe the walleye sport fisheries occurring along the south shore of Great Slave Lake while Hatfield et al. (1972a,b), Stein et al. (1973a,b), Jessop et al. (1973, 1974), Jessop and Lilley (1975) and Lilley (1975) provide comprehensive biological data on walleye occurring in the Mackenzie River and its many tributary streams.

Annual commercial production of walleye in the NWT has averaged over 40 000 kg (round weight) since the late 1970's. Over 95% of this production is taken from three lakes: Great Slave, Kakisa and Tathlina. An average of 44% of the total walleye production in the NWT comes from Kakisa Lake alone. Despite the importance of this fishery, scant information is available on this exploited walleye population.

In 1946, Kakisa Lake was first surveyed jointly by the Fisheries Research Board of Canada and the Department of Fisheries to determine whether it could support a commercial fishery for either lake whitefish or walleye (Kennedy 1962). As a result of the study whitefish were not recommended for commercial harvest due to a high infestation rate of the parasite, Triaenophorus crassus, but commercial fishing for walleye began on Kakisa Lake in the same year. Monitoring of the annual harvest however did not commence until the 1952/53 fishing season.

In 1968, the Department of Fisheries conducted a gillnetting survey of Kakisa Lake as part of a study to assess the commercial potential of various lakes in the NWT and to determine infestation rates of the parasite, Triaenophorus crassus in lake whitefish (Johnson 1976; Moshenko 1980). Lamoureux (1973) conducted a pre-impoundment study of Kakisa Lake and its surroundings in 1972 to assess the environmental impact of a proposed hydro-electric development of Lady Evelyn Falls on the Kakisa River, approximately 5 km downstream of Kakisa Lake. Biological sampling of the commercial catch, as part of the monitoring program, has only taken place since 1977.

Since the early 1970's fishermen have been requesting an increase in the annual walleye quota for Kakisa Lake. In response, the Department of Fisheries and Oceans (DFO) conducted an experimental gillnetting program in 1978 in order to determine whether the stock was capable of sustaining an increase in the harvest level. Information collected from this study combined with the data collected from the monitoring program is examined in this report. The status of the Kakisa Lake walleye stock is discussed and a management strategy, with total allowable catch (TAC), is recommended.

STUDY AREA

Kakisa Lake forms a part of the Kakisa River drainage basin (Fig. 1). The river system, 496 km long, originates west of the Cameron Hills and drains an area of 14 900 km^2 (Environment Canada 1980). The upper reaches of the river meander through low muskeg country occasionally flowing over small rapids and riffles. The water is stained a transparent brown, characteristic of most muskeg drainages. The river slows and deepens to 3 m before entering the west end of Tathlina Lake. The river flows out of the northeast corner of Tathlina Lake and is interrupted by several rapids dropping 55 meters in 25 km before entering the south side of Kakisa Lake.

Kakisa Lake (Fig. 2) is 40 km long and 12 km wide with a surface area of 33 126 ha (Kennedy 1962). The lake reaches a maximum depth of 7 m. Most of the shoreline consists of wave washed boulder, gravel or sand beach down to depths of 2-4 m. There is an abrupt change to silt substrate which characterizes the offshore bottom. The lake bottom in the sheltered west end of the lake is composed of black organic debris (Lamoureux 1973). The Muskeg River, at the east end of the lake, is the only major tributary (Fig. 2). Several small creeks drain into the lake along the south and west sides.

The outlet of Kakisa Lake is shallow and wide with a moderate current and is often choked with aquatic vegetation by midsummer. The river again drops 15 m over the Lady Evelyn Falls located 5 km downstream of the lake. This fall forms an effective barrier to the upstream migration of fish from Great Slave Lake (Fig. 2). The river continues as a series of smaller rapids flowing over a limestone bottom and enters Beaver Lake (Fig. 1) on the upstream end of the Mackenzie River.

THE FISHERY

The 1946 survey by the Fisheries Research Board of Canada concluded that Kakisa Lake had potential for a walleye (pickerel/dore) fishery but not a lake whitefish (Coregonus clupeaformis) fishery since the whitefish were heavily infested with the parasite, Triaenophorus crassus (Kennedy 1962). A gillnet fishery with an annual quota of 91 000 kg was established.

Allowable mesh size was 89 mm (stretched measure). As well an all weather road to Hay River from the lake was nearing completion which would ease transportation costs. The quota and mesh size were based on economic rather than biological considerations and the presumption that no lasting harm could be done to the walleye stocks. At a later time, adjustments to obtain maximum sustainable yield could be made once the fishery was in place.

McGinnes Fisheries Ltd. established the first commercial fishery on Kakisa Lake in the late 1940's. Production records for this period are not available. However, it was reported that "large" catches of walleye were taken on the lake for a couple of seasons (Art Delancey, DFO, Western Region, personal communication). Records of production began with the 1953 season. At this time the legal mesh size was increased to 114 mm (stretched measure) and the annual quota of 91 000 kg remained for the lake. This was modified for the 1958/59 season when a six year quota cycle was established with a total harvest of 89 000 kg. Theoretically, this harvest was to be taken during the first two years of the cycle with the lake remaining closed for the following four years to allow the walleye stock to recover. This cyclical system was in place until the 1967/68 season when the harvest level was again set on an annual basis. This annual quota was set at 18 700 kg with the legal mesh size remaining at 114 mm.

In 1977, commercial fishing on Kakisa Lake was restricted to the residents, upon their request, of the village of Kakisa Lake, a small Dene community on the northeast shore of the lake (Fig. 2). A fisherman was required to live in the village for six consecutive months to be eligible for a commercial license to fish the lake (NWT Fish. Reg. 1985). In 1980, the legal minimum mesh size was reduced to 108 mm (stretched measure).

Domestic fishing also takes place on Kakisa Lake. Kennedy (1962) estimated the maximum annual fish requirements of the Dene in the area to be less than 9 090 kg (20 000 lbs). Walleye and suckers were the species generally taken. Current estimates of the domestic catch are not available.

METHODS AND MATERIALS

COMMERCIAL FISHERY ASSESSMENT

Commercial production

Monthly summaries of the landings of walleye from Kakisa Lake were compiled from sales slips by DFO staff in Hay River since 1952. All data were recorded in pounds (round weight) until 1981 when the fishing industry in the NWT converted to the metric system, effective June 1981. The landings were recorded by season, commencing 1 November of one year through to 31 October of the subsequent year.

Catch per unit of effort (CPE)

Fishery observations were conducted on the Kakisa Lake commercial walleye fishery in July 1983 as part of the DFO monitoring program for inland commercial fisheries in the NWT. Summer staff were placed on board commercial fishing vessels to accompany the fishermen. Fishermen were interviewed for information pertaining to number of nets set, location and duration of sets, mesh size, mesh depth, twine size, depth fished, descriptive features of the fishing vessel and size of the crew. As the nets were lifted, observers kept a record of the number of fish caught and culled per net-gang. CPE was calculated as number and weight (kg) of fish caught per 91 m net per 24 h.

Biological evaluation

Sampling: Walleye from the commercial fishery were sampled at the fish plant in Hay River from 1977 to 1985, except in 1978 when virtually no commercial fishing took place. Boxes of fish were randomly selected from the catches of the various fishermen as they arrived in the plant. All walleye in each of these boxes were sampled for later biological analysis. At least three boxes were sampled in order to provide a minimum sample size of 215 fish.

Walleye were sampled for fork length (±1 mm), weight (±50 g), and aging structures (scales). Length was recorded as fork length when fish were sampled in the round (whole) or dressed (gutted) forms. Length of fish sampled in the headless dressed form was recorded and subsequently converted to fork length by the application of the following equation:

$$\text{Fork length} = 6.659 + 1.235\ (\text{headless length}).$$

Weight was recorded as round weight when fish were sampled in the round form. However when fish were in either the dressed or headless dressed form, weight was recorded and subsequently converted to round weight by the application of one of the following equations:

$$\text{Round weight} = 1.22\ (\text{dressed weight})$$
$$\text{Round weight} = -11.105 + 1.235\ (\text{headless dressed weight}).$$

The previous equations were derived from sampling 215 walleye in 1983 for fork length, round weight, dressed weight, headless dressed length and weight and subsequently performing linear regression analysis on these data.

Scales were removed from the left side of the walleye from the area just posterior to the pectoral fin and stored dry in coin envelopes. Scales were later mounted between two glass slides and the completed annuli counted on the image produced by an Eberbach microprojector (X60).

Length and age: Length- and age-frequencies were constructed to display catch composition by years. Student's t-test and Duncan's multiple range test were used to determine significant differences in age and length by year.

Growth: Weight-length relationships were calculated using least squares regression analysis on logarithmic transformations of fork length and round (or converted round) weights. Samples were initiall compared between years and then pooled and compared with other locations. The relationship is described by the following equation:

$$Log_{10}W = a + b\ (Log_{10}L)$$

where W = weight in grams
L = fork length in millimeters.

Mean fork length at age was plotted from samples taken in each year and visually compared. These data were then pooled and compared with growth curves from other locations.

Mortality: Instantaneous total mortality (Z) was calculated from the least squares regression line fitted to the descending limb of catch curves. Catch curves were fitted by eye and only that portion of the curve that appeared linear was included in the analysis. Moderate fluctuations in recruitment in different year classes tend to create an irregular shaped catch curve. To reduce these irregularities, samples from successive years were combined (Ricker 1975). Ricker (1975) indicated that the modal age in the catch curve will commonly lie quite close to the first year in which recruitment can be considered effectively complete. Therefore only the next older and subsequent age groups from the modal age were used.

Annual survival rate (S) and annual mortality rate (A) were calculated from Z. Instantaneous mortality rate (M) was estimated to be 0.34 calculated from the annual natural mortality (v) which was assumed to be 0.20 (Smith and Pycha 1961; Shuter and Koonce 1977). Instantaneous fishing mortality rate (F) was calculated from Z = F + M (Ricker 1975).

Rate of exploitation: The rate of exploitation (u) was calculated from the estimate of F as u = FA/Z after Ricker (1975), assuming that fishing and natural mortality operate concurrently.

Yield-per-recruit

The Beverton and Holt (1957) yield-per-recruit model was applied to aid in the assessment of the commercial fishery in Kakisa Lake utilizing the data obtained from the commercial samples of walleye taken in 1977 and 1979 to 1985 (excluding 1981). Yield-per-recruit analyses were performed using the BEVHOLT and VONB programs described by Rivard (1980). The VONB program used the von Bertalanffy growth equation (Ricker 1975) described as:

$$L_t = L\ (1 - e^{-K(t-t_0)})$$

where L_t = length at age t
L = mean asymptotic length
K = Brody growth coefficient
t_0 = hypothetical age at which a fish would have been zero length if it had always grown in a manner described by the equation.

This equation estimates the growth characteristics of the stock required for the Beverton and Holt model. The BEVHOLT program estimated the equilibrium yield including estimating population numbers and biomass, as well as catch numbers and weight from a given recruitment (Rivard 1980).

POPULATION ASSESSMENT

Experimental gillnetting

Experimental gillnetting was conducted in Kakisa Lake in July 1978 using standard gangs composed of panels of 47.5 m lengths each of 38, 64, 89, 114 and 139 mm mesh (stretched measure) nylon gillnets. A detailed description of the gillnets used is given in Appendix 1. A gap of 3 m was left between each panel to reduce leading of fish from one mesh size to another. Set locations were not chosen randomly but corresponded to the areas known to be utilized by commercial fishermen (Fig. 2). All sets were made on the bottom. The average set duration was 24 h. The catch was recorded by mesh size and by species. Biological samples were taken for later analysis. Catch per unit effort (CPE) was estimated as number and weight (g) of fish caught per 91 m net per 24 h.

Scientific names of all fish species caught followed Scott and Crossman (1973) as follows: walleye, Stizostedion vitreum (Mitchill); lake whitefish, Coregonus clupeaformis (Mitchill); lake cisco, Coregonus artedii Lesueur; northern pike, Esox lucius (Linnaeus); white sucker, Catostomus commersoni (Lacepede); and longnose sucker, Catostomus catostomus (Forster).

Biological evaluation

Sampling: All fish caught in the gillnets were sampled for fork length (±1 mm), round weight (±10 g), sex and stage of maturity. Sex and relative stage of maturity were determined by examination of the gonads. Relative stage of maturity was coded according to the stages described in Appendix 2. Subsequent to 1978 the maturity codes were rewritten and the codes assigned to walleye sampled in 1978 were altered to reflect this change. In this report, maturity stages coded 2 and 7 were omitted in the calculation of percent maturity since distinction between those fish that were virgin and those that were just resting could not be made when editing the 1978 codes. In the field it was also difficult to determine accurate maturity stages of walleye due to the July sampling period, i.e. post-spawning period. Gonads of spent walleye had already rejuvenated and were found similar in appearance to possible non-spawning (resting) walleye.

All fish caught in the gillnets were sampled for ageing structures (scales and fins). Scales were removed from the left side of the walleye from the area just posterior to the pectoral fin and from all other species as described by Hatfield et al. (1972a) and stored dry in coin envelopes. Scale ages were determined as described for walleye from the commercial samples. Dorsal fins were removed from a

sample of 95 walleye for comparison with scale ages. The fins were later embedded in epoxy, sectioned using a thin-sectioning machine and mounted on glass slides with a mounting medium DIATEX and the completed annuli counted using a disecting microscope (X30). For each fish the ages determined from fins were then compared to the ages determined from scales from the same fish to assess the reliability of aging using scales.

A qualitative analysis of the food types consumed by walleye caught from the experimental gillnets was made by examination of stomach contents. The food type was identified as being either fish remains (species unknown), benthic invertebrates, zooplankton or unidentifiable remains (Appendix 29).

Length and age: Length- and age-frequency histograms were constructed to display catch composition by mesh size and by year.

Growth: Weight-length relationships were calculated as described for the commercial walleye samples. Mean fork length at age was plotted from samples taken in different years and from different locations and growth rates were compared visually.

Relative condition factor (K), a measure of the plumpness of a fish, was determined using the formula:

$$K = \frac{W \times 10^5}{L^3}$$

where W = weight in grams
L = fork length in millimeters.

Condition factors were compared between years (t-test and analysis of variance) where data were available.

Mortality: Instantaneous total mortality (Z) was calculated from a least squares regression line fitted to the descending limb of the catch curve as described for the commercial walleye samples. Annual survival rate (S) and annual mortality rate (A) were calculated from Z.

DATA ANALYSIS

Data were analyzed using an Amdahl 5850 computer. Programs from Rivard (1980) were used for the Beverton and Holt yield-per-recruit model and Von Bertalanffy growth equation. The Statistical Analysis System (1982) was used for regression, t-tests and analysis of variance and to generate biological data summaries.

RESULTS AND DISCUSSION

COMMERCIAL FISHERY ASSESSMENT

Commercial production

Landings: Commercial landings of walleye since 1953 have annually averaged approximately 20 100 kg (excluding catches taken during the six-year quota cycles from 1959 to 1967). Landings of walleye from 1953 to 1985 ranged from a low of 5 095 kg to a high of 72 365 kg (excluding 1978 harvest) (Table 1). Prior to 1959 and the introduction of the six-year quota cycle system, annual harvest was approximately 21 900 kg. Fluctuations in landings during the 1950's are believed to be largely a result of effort rather than walleye abundance. The large catch taken in 1966 (72 365 kg) is believed to be the result of an increase in effort due to re-opening the lake to commercial fishing on a six-year quota cycle after a four year closure. Since resumption of an annual quota of 18 700 kg in 1968 production has remained relatively constant (Fig. 3) averaging approximately 19 400 kg annually. The noticeable harvesting over the allotted quota, in certain years, is primarily a result of enforcement logistics. Without constant monitoring of every delivery to the fish plant at Hay River, walleye landings from Kakisa Lake can often exceed the allowable catch.

The timing of the walleye harvest has altered since 1979 (Fig. 4). Fishing in 1979 and 1980 was mainly during the months of June, July and August and in 1981 extended into September and October. Since 1982, on average, approximately 90% of all walleye harvested were taken during the month of June from the area near the mouth of the Kakisa River downstream from Tathlina Lake (Fig. 2).

Yield: The commercial yield ($kg \cdot ha^{-1}$) of walleye has ranged from 0.15 to 2.18 $kg \cdot ha^{-1}$ (excluding 1978) (Table 1). Since 1972 the yield of walleye has remained relatively constant. It has decreased from a cumulative average of 0.66 $kg \cdot ha^{-1}$ in the 1950's (1953 to 1958) to 0.58 $kg \cdot ha^{-1}$ in the 1980's (1980 to 1985). If it is assumed that the harvest of walleye by the domestic fishery on Kakisa Lake is $\leq$9 000 kg as based on historic information (Kennedy 1962) then the total yield of walleye would be placed at $\leq$0.93 $kg \cdot ha^{-1}$ in the 1950's and $\leq$0.85 $kg \cdot ha^{-1}$ in the 1980's which is in the upper range for yields reported for other commercial walleye fisheries. In comparison, commercial walleye yields from five lakes in northern Saskatchewan averaged 0.88 kg/ha (range = 0.4-1.6 $kg \cdot ha^{-1}$) (Rawson 1957a) and 0.20 $kg \cdot ha^{-1}$ for Lac la Ronge, Saskatchewan (Rawson 1957b). Koshinsky (1965) estimated an average yield of 0.33 $kg \cdot ha^{-1}$ (range 0.04-0.71 $kg \cdot ha^{-1}$) for five Precambrian lakes near Lac la Ronge. Walleye yields calculated for seventy (70) lakes in northern Ontario averaged 0.49 $kg \cdot ha^{-1}$ (Adams and Olver 1977). Adams and Olver (1977) determined that lakes in northern Ontario have a total percid sustainable yield of 1.00-1.25 $kg \cdot ha^{-1}$ for moderate to intensively fished lakes.

Catch per unit of effort (CPE)

Fishery observations conducted in June 1983 showed that walleye composed 83% of all fish caught (Table 2). All other species caught including northern pike, white sucker and burbot were culled on the lake. A total of 3 057 walleye were caught using 5 824 m of nets. The

average CPE was 80.0 kg/91 m net/24 h (95.5 fish/91 m net/24 h) (Table 2). In comparison, Regier et al. (1969) estimated CPE for walleye from western Lake Erie from 1948-61 to range from 0.38 to 5.69 kg/91 m net for small mesh gillnets and from 0.62 to 15.25 kg/91 m net for large mesh gillnets. Ryder's (1968) estimate of CPE for walleye from Nipigon Bay 1954-65 ranged from 0.45 to 3.00 kg/91 m net/24 h. The very high CPE for walleye from Kakisa Lake is attributed to site specific fishing (Fig. 2). Fishermen, during the course of the interviews (21-25 June), set their nets in the area at the mouth of the Kakisa River leading from Tathlina Lake. They believed that the walleye spawning run located upstream in the river was about completed and the fish were moving back downstream and congregating in the river mouth in order to feed. Movement of walleye upstream to spawning areas and then back downstream subsequent to spawning is characteristic of many walleye populations (Colby et al. 1979; Thorn 1984; Bodaly 1980). In order to corroborate the high CPE from the Kakisa Lake commercial fishery, a net was set by DFO personnel towards the centre of the lake during this time. The net caught only two walleye providing a CPE of 1.7 kg/91 m net/24 h. Therefore the very high CPE for walleye from Kakisa Lake discussed earlier is considered to be biased due to the timing and location of the fishery and cannot be considered a reliable measure of relative abundance as described by Ricker (1975).

Biological evaluation

Length and age: Mean length of walleye from the commercial fishery from 1977 to 1985 ranged from 378 mm to 410 mm (Table 3) while modal length ranged from 360 mm to 420 mm (Fig. 5). Analysis of variance indicated a significant difference ($P<0.01$) in mean length ($F = 18.6$, 5 df) between years. Duncan's multiple range test performed on fork length for the years sampled indicated a significant difference ($P<0.05$) for length of walleye between 1977-80 and 1983-85. There is a notable decrease in the percent occurrence since 1982 of walleye at length intervals <350 mm and an increase at length intervals 410-450 mm (Table 3).

There was no significant difference ($P>0.05$) in the ages of walleye determined using scales and fins (Appendix 3). Eighty-five percent of the fish aged had only ±0-1 year difference. Therefore variability in aging walleye from Kakisa Lake using scales is assumed to be minimal.

Mean age of walleye ranged from 8.6 yr to 10.6 yr (Table 4). Modal age ranged from 9 to 11 yr (Fig. 6). Scale ages for the 1981 walleye sample were significantly different ($P<0.001$) from other years and were not considered in the biological evaluation of the commercial fishery. This difference is attributed to incorrect sampling whereby scales were removed from the lower side of the fish resulting in the removal of smaller size scales. This resulted in difficulty in identifying individual annuli and in turn, caused the ages to be underestimated by 3-4 yr based on comparative age at size from other years.

Analysis of variance indicated a significant difference ($P<0.01$) in mean age ($F = 227.8$, 5 df) between years. Duncan's multiple range test performed on age for the years sampled indicated a significant difference for ages of walleye between 1977-79 and 1982-85. There is a noticeable shift in the age distribution since 1982 towards fish older than 11 yr and a concurrent decrease in fish age 8 yr and younger (Table 4).

The results of this study indicate a shift in distribution in the commercial harvest of walleye from 1977-80 to 1982-85 towards larger (Fig. 5) and older (Fig. 6) fish. However, it is interesting to note that the modal length and in particular the modal age has not significantly increased during this same time period. The commercial catch from 1977 to 1979 depended primarily on fish aged 7-9 yr (mode = 9 yr) while from 1980 to 1985 the catch was composed of 9-11 age groups (mode = 10 yr). Smith and Pycha (1961) found that the extreme variation in contribution of each age group of walleye from the commercial fishery from Red Lakes in different years was the function of both the strength and growth history of different year classes. Colby and Nepszy (1981) state that an increase in mean age can result from lack of recruitment or increased survival. In Kakisa Lake, the increase in mean age does not appear to be from a lack of recruitment since the modal age has remained relatively stable at 10 yr since 1980.

Strong year classes 1970 and 1971, possibly resulting from the lower harvests taken prior to and during those years, are apparent (Fig. 6) and may contribute to the increase in both the size and age of walleye from 1977-79 to 1982-85. The poor representation of older fish (ages 12-15 yr) in 1977 may be related to an increase in exploitation of walleye during the late 1950's when harvest levels averaged 27 000 kg (Table 1). Alm (1977) found that one strong year class in perch populations remains dominant for several years. In the case of dystrophic lakes a strong year class may remain predominant for approximately 15 years while in small eutrophic lakes it remains for less than 10 years. Parsons (1970), Smith (1977), and Smith and Pycha (1961) noted that fluctuations in year class strengths contributed to the variable walleye contributions to the Lake Nipissing fishery. Busch et al. (1975) demonstrated that Lake Erie walleye spawning success on lake shoals was important in determining year class strength. Ward and Clayton (1975) also found that the age distribution of walleye from West Blue Lake was unstable and probably reflected spawning success. Bodaly (1980), Chevalier (1977), Derksen (1967), Koonce et al. (1977), Nelson and Walberg (1977), Olson and Scidmore (1962), Priegel (1970), and Spangler et al. (1977) indicate the importance of spring water levels and flows, water temperature and wind on walleye spawning success and the effects of these to the timing of the runs. However, abiotic factors contributing to variations in timing of the spawning and post-spawning runs of walleye from 1977 to 1985 are unknown and therefore the extent, if any, of their contributions to the differences in the size and age composition of the commercial catch during this same period is not assessed.

Studies have indicated that the sex ratio of walleye during the spawning runs varies (Rawson 1957b; Johnson 1971; Bodaly 1980). Falk et al. (1980) found that females caught in the fish weir in Mosquito Creek, NWT tended to be larger and older than male walleye. Other studies have shown that males tend to move onto the spawning grounds first and remain longer while females stay for shorter periods, probably just to spawn, and then migrate back out into the lake (Colby et al. 1979; Eschmeyer 1950; Rawson 1957b; Payne 1963; Priegel 1970; Bodaly 1980). It has also been found that there is a large amount of variation in the dispersal of individual fish away from spawning sites (Eschmeyer 1950; Eschmeyer and Crowe 1955; Rawson 1957b; Forney 1963; Bidgood 1967; Bodaly 1980). Therefore the size and age composition of walleye caught in the commercial fishery may vary depending upon the timing of the post-spawning run since the Kakisa Lake fishermen fish the post-spawning run at the river mouths (Fig. 2), in particular since 1982 when on average over 90% of the walleye were harvested during June (Fig. 4). Unfortunately, the sex of walleye utilized by the commercial fishery are not able to be determined and therefore variations in size and age vs sex of the post-spawning run cannot be assessed.

It has been noted since 1983 that fishing takes place only in the area around the mouth of the Kakisa River leading from Tathlina Lake. Prior to this time it is believed that some fishing was done around the mouth area of the Muskeg River and possibly other areas around the lake. In 1977, the commercial catch consisted of samples from at least three different fishermen of which the mean size and age of walleye were significantly different. This difference may be the result of fish being taken from different areas (i.e. Kakisa and Muskeg rivers). This may be a contributing factor to the differences in size and age compositions noted between 1977-80 and 1982-85.

Another factor often noted to cause changes in the size and age composition of the catch is a change in gear, i.e. mesh size. Prior to 1981 the legal minimum mesh size utilized by the commercial fishery was 114 mm. In 1981, the mesh size was decreased to 108 mm although, during that year both 108 and 114 mm meshes were used while subsequently only 108 mm mesh was utilized. However, with a decrease in mesh size an increase in mean length and age has occurred. Johnson (1976) states that size of fish taken in any mesh is dependent not wholly on the mesh size to select any particular size group but on the fish present. This would therefore indicate that regardless of the decrease in mesh size, the availability of smaller and younger fish has decreased.

Growth: Comparison of the weight-length relationships for walleye by year is shown in Table 5. Round weights (excluding 1981-82 headless dressed weights) were compared by analysis of variance. Means for all years were not significantly different ($P>0.01$).

Mean length-at-age of walleye from the commercial fishery is similar for all years surveyed. Analysis of variance indicated no significant difference ($P>0.05$) in mean length-at-age ($F = 0.33$, 5 df).

Colby et al. (1979) suggest that the growth rate of adult walleye is affected by temperature and the amount of food consumed. Food consumption in turn is related to forage abundance and population density. Moenig (1975) observed an increase in growth rate with exploitation while Colby et al. (1979) found that stocks undergoing heavy exploitation show a rapid increase in growth and result in a severe decline in abundance. Since very little change in growth has occurred from 1977 to 1985 this suggests that the Kakisa Lake walleye are not being over-exploited by the commercial fishery and that temperature and amount of food consumed appear not to have had a significant effect on growth during that time period.

The relative condition factor (K) of walleye is not significantly different ($P>0.05$) from 1977 to 1985 ranging from 1.20 to 1.27 for those fish sampled in the round weight form. Colby et al. (1979) presents K values for walleye from various waters ranging from 0.81 to 1.85. Carlander (1944) indicates a K value >1.02 to signify that walleye are in excellent condition. Food availability appears to be the main factor in determining the condition of adult walleye (Colby et al. 1979).

Mortality: Total instantaneous mortality (Z), as derived from catch curves, are presented in Fig. 7. From 1977 to 1985 Z ranged from 0.64 to 1.19 (Table 6). Colby et al. (1979) found that Z ranged from 0.14 to 1.83 for walleye in various lakes but the common rates ranged between 0.51 and 0.80. Ney (1978) states that in exploited populations Z ranged as high as 0.85. If a constant natural mortality rate ($M = 0.34$) is assumed then the changes in Z would be the result of changes in fishing mortality (F).

There is a notable increase in F from 1977 to 1979-80 with a resultant decrease in the harvest of fish older than 12 yr (Fig. 6). Then inexplicably in 1982 the catch takes larger-older fish with a resultant decrease in F. Throughout this time the commercial harvest levels have remained relatively constant, however, the extent, if any, of harvest by the domestic fishery is not known. If domestic fishing was increased this would have resulted in an increase in F. Subsequently, a change in the fishing location and strategy towards the harvest of larger-older fish would cause a change in mortality rates. As previously discussed there may be a size-age difference between fish harvested from the Kakisa and Muskeg rivers. If the fishermen altered the locations fished and directed their efforts to harvesting the larger-older post-spawners, this may be a reason for the decrease in F since 1982. The decrease in mesh size from 114 mm to 108 mm mesh in 1981 is not believed to cause any significant change in the size-age composition of fish being commercially exploited and therefore in F.

Yield per recruit

Beverton and Holt (1957) yield-per-recruit curves for the years 1977 to 1985 (excluding 1978 and 1981) indicate the optimal ($F_{0.1}$) and maximum (F_{max}) levels of fishing mortalities for each year (Fig. 8). Optimum fishing mortality ranged from 0.40 to 0.55. In 1977 calculated fishing mortality was less than $F_{0.1}$. From 1979 to 1983 fishing mortality exceeded $F_{0.1}$ Subsequently in 1984 and 1985, F was considerably lower than $F_{0.1}$. Maximum fishing mortality (F_{max}) was extremely high in all years analyzed ranging from 11.6 to 12.6. This excessively large F_{max} indicates that the yield-per-recruit curves are nearly asymptotic and that the calculated value of F_{max} and the corresponding derivatives (i.e. $F_{0.1}$) may be inaccurate (Rivard 1980).

Optimum fishing mortality ($F_{0.1}$) values were substituted into the Baranov catch equation to calculate conservative estimates of total allowable catch (Table 7). The annual yields calculated ranged from 11 734 kg to 31 904 kg (mean = 19 884 kg). Ricker (1975) identifies and explains the limitations of the Baranov catch equation as it applies to the relationship between equilibrium yield to stock size and rate of fishing. The equation can be used, at best, as an approximation of total allowable catch (Kristofferson et al. 1982). However, factors affecting the reliability of these estimates include the significant variability in the calculated fishing mortalities (F), the possible inaccuracy of the $F_{0.1}$ values and the unknown extent of harvest by the domestic fishery. Estimates of total allowable catch must therefore be designed to be conservative and be based, to a large extent, on the past history of the fishery in order to ensure the continual sustainability of the fishery and not just on mathematical models and equations.

POPULATION ASSESSMENT

Experimental gillnetting

A total of 1 712 fish were caught from the seven (7) experimental gillnet gang sets in Kakisa Lake during 1978 (Fig. 2). Walleye (84.1%), northern pike (6.9%), and lake whitefish (4.0%) composed 95% of the total catch (Table 8). Other species included least cisco, longnose sucker, white sucker and burbot. Overall catch per unit of effort (CPE) was 148.7 fish per 91 m of gillnet per 24 h. Compared to the catch composition in 1946 (Kennedy 1962) and 1968 (Johnson 1976; Moshenko 1980) walleye still remains the dominant fish species in Kakisa Lake.

Catch per unit effort for walleye in 1978 ranges from 10.4 fish/91 m net/24 h in the 139 mm mesh to 302.8 fish/91 m net/24 h in the 64 mm mesh (Table 9). Availability of walleye by mesh size has changed since the start of commercial fishing in 1946. Comparison of catches in 1946 and 1978 shows an increase in CPE in the 38 and 64 mm mesh and a slight decrease in CPE in the 139 mm mesh from 12.0 fish per unit effort to 10.4 fish per unit effort (Table 9). This is probably the result of fishing down the number of larger fish in the stock.

There is a significant difference ($P<0.05$) between mean length (Fig. 9) and mean age (Fig. 10) of walleye caught by each mesh size but the modal length and age vary only slightly. Johnson (1976) states that this results from each mesh size having a minimum size of fish that it retains but no maximum. However, there is a definite bimodal distribution in the 114 mm mesh and possibly the 139 mm mesh although the small sample size in the latter mesh size makes comparisons difficult. This tends to suggest that the larger mesh sizes select for larger-older walleye as well as smaller-younger fish, however it may be that the larger meshes catch small fish by hooking the teeth and spines while the larger-size fish are caught by gilling. Johnson (1976) however, believed that the size of fish taken in any mesh size is dependent on the fish present rather than on the selectivity of the net to any particular size.

The modal size of walleye caught by each mesh size has remained remarkably constant over time. When the 1978 data are grouped into 5 cm length intervals and compared with that found in 1968 there is little variation between meshes, in particular the 38-89 mm meshes (Fig. 11). The skewness towards the left of the length distribution of walleye taken in the 114 mm mesh in 1968 and the lack of a bimodal distribution are probably due to the removal of larger-sized fish by heavy exploitation by the commercial fishery in 1966. Therefore, it seems apparent that the segment of the stock which has been most affected by commercial exploitation since the 1960's is the larger-older fish although the extent is not believed to be extensive.

The 64 mm mesh generally caught greater than twice as many walleye as did any other mesh size and had the highest mean biomass (Fig. 12). Mean number of fish and mean biomass declined rapidly from the 64 mm to the 139 mm mesh. Frequency of immature walleye were found to decline with an increase in mesh size (Table 10). The increase in percent frequency in the 114 and 139 mm is not considered significant due to small sample sizes. Lysack (1980) found the percent of immature walleye from northern Lake Winnipeg to decline with increasing mesh size as well. Unfortunately, no data is available on the mean number of fish, mean biomass or the frequency of immature walleye caught in the 108 mm mesh, the gear currently utilized in the commercial fishery. However, it is assumed that these missing values would be less than that found in the 114 mm mesh, but greater than that for the 89 mm mesh. It is suggested therefore that the large legal minimum mesh size of 108 mm used in the Kakisa Lake commercial fishery is protecting a large pre-recruited fraction of the stock consisting of small and immature fish. This large fraction of the total biomass is required in order to sustain the reproductive capacity necessary for a sustainable commercial fishery.

Biological evaluation

Length, age and maturity: Walleye caught by the experimental gillnets in 1978 ranged from

120 mm to 560 mm fork length (mean = 337 mm) (Table 11). The larger mean length of males and females compared to the combined is due, in part, to unsexed fish as well as to those fish sexed but classified as maturing and therefore omitted from the sexed calculations. In comparison, the mean length of walleye in 1946 (Kennedy 1962) and 1968 (Moshenko 1980) was 428-453 mm (mean length group) and 325 mm, respectively. Modal lengths between 1968 and 1978 were similar, (300-350 mm) while the modal length of walleye sampled in 1946 was 450 mm (Fig. 13). The decrease in modal size from 1946 to 1968 is attributed to the fishing down of the larger and older walleye present prior to the onset of commercial exploitation.

Mean age of walleye in 1978 was 7.6 yr. The difference between mean age of males and females and the combined age is due to the exclusion in the calculation of unsexed fish and fish sexed but classified as maturing (Table 12). In comparison the mean age of walleye in 1968 (Moshenko 1980) and 1946 (Kennedy 1962) was 7.1 and 8.4 yr respectively. There was no change in the modal age of 8 yr between 1946, 1968 and 1978 (Fig. 14). However, there is a decrease in percentage of older fish from 1946 to 1978. The paucity of older fish in 1968 may be due to heavy exploitation of that segment of the population in 1966 when the lake was again reopened to commercial fishing (Table 1).

Age at maturity varies considerably between walleye stocks and generally correlates inversely with growth rate (Colby et al. 1979). Northern stocks are found to mature later and over a greater number of years than southern stocks (Colby et al. 1979) and heavily exploited stocks mature earlier than lightly or unexploited stocks (Wolfert 1969; Spangler et al. 1977). Kennedy (1962) states that most 7 yr old walleye taken from Kakisa Lake in 1946 were mature. In 1978 walleye were identified as mature as young as age 4 yr (Table 12) and 166 mm fork length (Table 11), and were not completely mature until age 10 yr and 394 mm fork length.

The earlier maturity found in 1946 may be due to the sampling of the faster growing segment of the population available prior to commercial exploitation. Forney (1965) found a trend toward an earlier maturity within the more rapidly growing walleye from Oneida Lake, New York. In comparison, Rawson (1957b) reported that few walleye in Lac la Ronge, Saskatchewan, spawned at age 5 but the majority were mature at age 8-10 yr.

Scott and Crossman (1973) and Colby et al. (1979) report that male walleye mature at an earlier age than females. Male and female walleye, in 1978, were found to be mature as young as age 4 yr (Table 12) and at 178 mm and 166 mm, respectively (Table 11). Male walleye were completely mature at age 10 yr and 384 mm while female were age 10 yr and 394 mm. In comparison, Bond et al. (1978) reported that male walleye do not spawn before reaching age 7 yr and females before age 8 yr in the Hay River, NWT. During the spawning run of walleye into the Mosquito Creek, NWT from 1973-78, males were found to be mature ranging from 6-17 yr and females from 8-16 yr (Falk et al. 1980).

Growth: The weight-length relationship for walleye (sexes combined) from Kakisa Lake, 1978 was determined to be:

$$\log_{10}W = -4.518 + 2.831 \log_{10}L$$

There was no significant difference ($P>0.05$) between male and female walleye. In comparison, Colby et al. (1979) found no significant difference between the weight-length relationships of males and females in various other waters studied.

Increases in weight for a given length for walleye in 1978 were not notably different from that found for walleye in 1968. No comparison could be made with those caught in 1946 due to the differences in the data recording formats. This lack of a difference in growth between 1968 and 1978 indicates that Kakisa Lake walleye are not being heavily exploited. Increases in growth rates have been observed in walleye stocks undergoing heavy exploitation which ultimately resulted in severe declines in abundance (Colby et al. 1979; Spangler 1977).

Growth rate for Kakisa Lake walleye is compared with that of walleye from other lakes (Fig. 15). Kakisa Lake walleye appear to be slow growing in this comparison. Their growth is similar to that found for walleye from Tathlina Lake, NWT (M. Roberge, DFO, Western Region, unpublished data) but lower than that found for walleye from Dogface Lake, NWT (M. Roberge, DFO, Western Region, unpublished data), Hay River, NWT (Bond et al. 1978) and other southern populations. The Kakisa Lake growth rate appears to decline after the walleye reach approximately 13 yr of age. This low growth rate is probably related to the northern location of Kakisa Lake. Colby et al. (1979) found that the growth rate of walleye decreases with increasing latitude. They also found that growth may be affected by temperature, forage abundance and population density.

Mean condition factor (K) was 1.15 in 1978; 1.15 for males and 1.14 for females (Table 12).

Mortality: Catch curve analysis indicated a good fit to the regression line fitted to that portion of the descending limb of the curve considered, by visual observation, to be linear (Fig. 16). Fluctuations in the descending limb are probably due to variability in recruitment. Instantaneous total mortality (Z), calculated from the slope of the straight line fitted to the data, was estimated to be 0.80 (Fig. 16). Annual survival rate (S) is low at 0.45. In comparison instantaneous mortality rate (Z) was 0.48 in 1946 (Kennedy 1962) and S was 0.62. Instantaneous mortality rate (Z) was not estimated for 1968 due to the non-representation of older age classes in the sample. If an instantaneous natural mortality (M) is assumed to be 0.34 then the difference in 1946 represents an instantaneous fishing mortality of 0.14 which may reflect of exploitation by domestic fishing which took place prior and subsequent to commencement of commercial fishing.

CONCLUSIONS

Commercial production of walleye from Kakisa Lake has fluctuated since the establishment of the fishery in 1946. Unfortunately, no production records are available for the first seven years but it is believed that walleye were readily available. The fluctuations in commercial production from 1953 to 1985, excluding the harvest taken during the six year quota cycles, are attributed to variations in fishing effort rather than changes in abundance.

Since 1977 the monitoring and biological samples of the commercial fishery have provided continuous information on the harvest and biological status of the exploited segment of the walleye population. Over-exploitation of this segment has not been demonstrated to date. Growth rates have not increased but remain relatively unchanged as does the relative condition of walleye. Recruitment overfishing is not evident with the modal size and age not having altered to any great extent over the sampling period even though the mean size and age have increased significantly from 1977 to 1985. The differences from year to year may be due to changes in the timing and location of fishing with some influence caused by fluctuations in year class strength. The impact of abiotic factors such as water temperature and flow, etc. on year class strength are not known. Fluctuations in instantaneous total mortality are considered due to changes in fishing mortality if a constant natural mortality is assumed. These changes may result from changes in the timing and location of fishing providing for the harvest of larger-older fish. The effects of the gear (mesh size) change on fishing mortality are not believed to be significant in this instance. However, a factor which may have had a significant effect in bringing about changes in fishing mortality is the impact by the domestic fishery. Unfortunately, the extent of this fishery during this time is unknown and thus the amount of its influence cannot be assessed.

The commercial exploitation of walleye since 1946 does not appear to have had an impact on the fish community at large; walleye still remained the dominant fish species of Kakisa Lake in 1978. However, it did result initially in fishing down the larger-older walleye in the population. The possible effect of what long-term heavy exploitation can do is evident in 1968 by the paucity of older fish after a few years. Growth rates have not altered significantly from 1968 to 1978 while age-at-maturity has not decreased since 1946; these two responses are indicative that the stock was not subjected to long-term over-exploitation.

Application of the Beverton and Holt yield-per-recruit model also verified that the Kakisa Lake walleye were not being over-exploited from 1977 to 1985, assuming that the model accurately portrays the response of walleye to exploitation. The estimates of total allowable catch (TAC), calculated using the Baranov equation and considering the limitations of the catch equation and the possible inaccuracy of the $F_{0.1}$ values used, should only be used as a guideline when determining the TAC. Setting a high quota, as shown in 1968, can have serious effects on walleye and may lead to over-exploitation with a resultant demise of a valuable fishery in the NWT. Therefore, considering the past history of the fishery and using the estimated TAC as a guideline, the commercial TAC should not exceed 20 000 kg. This TAC is conservative since an allowance must be made for the harvest by the domestic fishery which has not been included in this estimate.

The decrease in mesh size from 114 mm to 108 mm does not appear to have had any significant effect on the exploited segment of the population. Unfortunately, information as to the frequency of immature walleye caught by the 108 mm mesh is unavailable. Assuming that it would be less than that found for the 114 mm mesh but greater than that for the 89 mm mesh, it is believed that the minimum mesh size of 108 mm is protecting a large fraction of the pre-recruits which is necessary to sustain a long-term commercial fishery.

MANAGEMENT RECOMMENDATIONS

1. Total allowable commercial catch should not exceed 20 000 kg assuming that the domestic catch is <9000 kg.

2. Annual monitoring and biological sampling of the commercial catch should continue in order to provide information on the status of the exploited walleye stock.

3. Annual monitoring of the domestic fishery should be initiated in order to provide a current estimate of the domestic harvest.

4. The TAC should be reviewed within five years and adjustments made pending any observed changes in fishing strategies and stock composition.

5. Research into the population dynamics of walleye in its northern range is needed including the effects of exploitation.

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Table 1. Annual catch and yield of walleye from the commercial fishery, Kakisa Lake, 1953-1985.

Season[1]	Quota (kg)	Catch (kg)	Yield ($kg \cdot ha^{-1}$)
1953	91 000	16 286	0.49
1954	"	32 563	0.98
1955	"	5 095	0.15
1956	"	29 616	0.89
1957	"	25 884	0.78
1958	"	22 160	0.67
1959	89 000[2]	32 027	0.97
1960	"	25 414	0.77
1961	"	17 878	0.54
1962	closed	-	-
1963	closed	-	-
1964	closed	-	-
1965	closed	-	-
1966	89 000[3]	72 365	2.18
1967	"	27 124	0.82
1968	18 700[4]	15 741	0.48
1969	"	15 169	0.46
1970	"	14 534	0.44
1971	"	28 851	0.87
1972	"	21 813	0.66
1973	"	21 537	0.65
1974	"	20 155	0.61
1975	"	20 200	0.61
1976	"	17 374	0.52
1977	"	19 745	0.60
1978	"	278	0.01
1979	"	19 808	0.60
1980	"	18 727	0.54
1981	"	18 144	0.55
1982	"	17 501	0.53
1983	"	21 874	0.66
1984	"	19 278	0.58
1985	"	20 443	0.62

[1] Season extends from November 1 of the previous year to October 31 of the year listed.

[2] Quota based on six year cycle: 2 years open, 4 years closed. In 1961 the lake was left open in order to allow for harvesting of the remainder of quota not taken in 1959-60.

[3] Quota based on six-year cycle.

[4] Reverted back to annual quota.

Table 2. Catch and catch per unit effort for all fish combined (total) and walleye from fishery observations, Kakisa Lake, 1983.

Date	Duration of Set (h)	No. of Gangs	Total No. of Nets	Total Net Length (m)	Catch		CPE		
					Total (no.)	Walleye (no.)	Total (no.)[1]	Walleye (no.)[1]	Walleye (kg)[2]
June 21	12	2	4	364	368	338	184.0	169.0	141.6
	12	1	4	364	359	335	179.5	167.5	140.4
	12	2	4	364	285	239	142.5	119.5	100.1
June 22	12	2	4	364	252	194	126.0	97.0	81.3
	12	2	4	364	220	188	110.0	94.0	78.8
	12	1	4	364	448	387	224.0	193.5	162.2
	12	1	4	364	73	49	36.5	24.5	20.5
	12	2	4	364	275	197	137.5	98.5	82.5
	12	2	4	364	131	100	65.5	50.0	41.9
June 23	12	2	4	364	210	137	105.0	68.5	57.4
	12	1	4	364	292	220	146.0	110.0	92.2
	12	2	4	364	155	101	77.5	50.5	42.3
June 25	12	3	8	728	262	238	65.5	59.5	49.9
	12	4	8	728	371	334	92.8	83.5	70.0
Total		27	64	5824	3701	3057	115.7	95.5	80.0

[1]No. of fish/91 m net/24 h.

[2]Kg fish/91 m net/24 h.

Table 3. Mean length and length-frequency of walleye from the commercial fishery, Kakisa Lake, 1977-85.

Year	No. of Fish	Mean Length (mm)	Percent				
			≤350	360-400	410-450	460-500	>500
1977	460	393	22	47	25	5	1
1978	-	-	-	-	-	-	-
1979	196	378	26	62	11	1	-
1980	111	389	19	58	22	-	2
1981	213	396	13	57	27	1	1
1982	210	398	10	55	33	1	-
1983	210	410	3	45	51	1	-
1984	211	405	2	59	36	3	-
1985	210	409	2	51	41	5	<1

Table 4. Mean age and age frequency of walleye from the commercial fishery, Kakisa Lake, 1977-85.

Year	No. of Fish	Mean Age (yr)	Percent										
			5	6	7	8	9	10	11	12	13	14	15
1977	357	8.6	<1	8	22	22	24	11	6	4	1	1	1
1978	-	-	-	-	-	-	-	-	-	-	-	-	-
1979	177	8.6	-	2	8	33	46	8	2	1	-	-	-
1980	107	9.5	-	-	7	12	29	38	9	1	1	1	1
1981	-	-	-	-	-	-	-	-	-	-	-	-	-
1982	201	10.4	-	<1	2	10	11	20	34	15	5	-	<1
1983	201	9.9	-	-	2	15	23	25	20	10	3	<1	-
1984	205	10.6	-	-	-	1	20	31	22	16	7	2	-
1985	201	10.6	-	<1	-	1	15	33	32	7	6	2	2

Table 5. Weight-length relationship, $\log_{10} W = a + b(\log_{10} L)$, for walleye from Kakisa Lake, 1977-85.

Year	No. of Fish	Y-intercept (a)	Slope (b)	Standard Error of b (S_b)
1977	169	-4.11	2.68	0.06
1979	-	-	-	-
1980	106	-4.38	2.78	0.06
1981[1]	196	-2.14	1.95	0.18
1982[1]	200	-2.87	2.23	0.09
1983	209	-3.94	2.62	0.08
1984	210	-3.37	2.41	0.07
1985	200	-3.43	2.44	0.08

[1]Converted lengths and weights.

Table 6. Instantaneous total and fishing mortality, exploitation and annual survival rates of walleye from the commercial fishery, Kakisa Lake, 1977-85.

Year	Age (yr)	Instantaneous Total Mortality (catch curve) Z	Instantaneous Fishing Mortality (Z-0.34) F	Exploitation $(1-e^{-F})$ μ	Annual Survival S
1977	11-14	0.66	0.32	0.27	0.48
1979	9-11	1.18	1.84	0.57	0.31
1980	10-12	1.19	0.85	0.57	0.30
1982	11-13	0.92	0.58	0.44	0.40
1983	11-13	0.97	0.63	0.47	0.38
1984	11-13	0.64	0.30	0.26	0.53
1985	11-14	0.66	0.32	0.27	0.52

Table 7. Estimated yield of walleye at $F_{0.1}$ using the Baranov equation for Kakisa Lake, 1977-85.

Year	Catch (kg) C	Instantaneous Total Mortality (catch curve) Z	Instantaneous Fishing Mortality (Z-0.34) F	Population Size (kg) $N = \frac{CZ}{FA}$	Optimum Instantaneous Fishing Mortality $F_{0.1}$	Catch (kg) at $F_{0.1}$ $C = \frac{NFA}{Z}$
1977	19 745	0.62	0.28	95 046	0.40	26 716
1979	19 808	1.18	0.84	40 327	0.49	13 332
1980	18 727	1.19	0.85	37 454	0.45	11 734
1982	17 501	0.92	0.58	46 267	0.40	13 005
1983	21 874	0.97	0.63	54 321	0.48	17 807
1984	19 278	0.64	0.30	87 503	0.55	31 904
1985	20 443	0.66	0.32	87 841	0.40	24 690

Table 8. Catch and catch per unit effort (CPE) for fish caught by experimental gillnets from Kakisa Lake, 1978.

		Mesh Size (mm)					Total Catch	CPE[1]
		38	64	89	114	139		
Walleye	No.	285	697	377	56	24	1 439	125.0
	%	19.8	48.4	26.2	3.9	1.7	84.1	
Northern pike	No.	25	46	37	8	2	118	10.3
	%	21.2	39.0	31.4	6.8	1.7	6.9	
Lake whitefish	No.	9	15	36	6	3	69	6.0
	%	13.0	21.7	52.2	8.7	4.3	4.0	
Lake cisco	No.	29	-	-	-	-	29	2.5
	%	100.0	-	-	-	-	1.7	
Longnose sucker	No.	4	4	5	2	-	15	1.3
	%	26.7	26.7	33.3	13.3	-	0.9	
White sucker	No.	4	5	20	4	8	41	3.6
	%	9.8	12.2	48.8	9.8	19.5	2.4	
Burbot	No.	-	-	1	-	-	1	0.1
	%	-	-	100.0	-	-	0.1	
Total	No.	356	767	476	76	37	1 712	148.7
	%	20.8	44.8	27.8	4.4	2.2		

[1] No. fish/91 m gillnet/24 h.

Table 9. Catch per unit effort (no. fish/91 m net/24 h) by mesh size of walleye from Kakisa Lake, 1946 and 1978.

Year	Mesh Size (mm)					
	38	64	89	114	120	139
1946 (Kennedy 1962)[1]	6.0	76.0	-	-	36.0-64.0	12.0
1978 (this study)	123.8	302.8	163.8	24.3	-	10.4

[1]Assume an overnight set = 12 h.

Table 10. Percent occurrence of immature male and female walleye in each mesh size, Kakisa Lake, 1978.

Sex		Mesh Size (mm)				
		38	64	89	114	139
Male	No.	146	311	191	34	11
	% Immature	27.4	25.4	13.6	23.5	18.2
Female	No.	83	287	156	22	12
	% Immature	12.0	11.8	3.8	0.0	25.0
Combined	No.	229	598	347	56	23
	% Immature	21.8	18.9	9.2	14.3	21.7

Table 11. Biological data by length interval for yellow walleye caught by experimental gillnets, Kakisa Lake, 1978.

LENGTH INTERVAL (MM)	MALES						FEMALES						COMBINED					
		LENGTH(MM)	WEIGHT(G)			%		LENGTH(MM)	WEIGHT(G)			%		LENGTH(MM)	WEIGHT(G)			%
	N	MEAN	MEAN	SD	K	MAT	N	MEAN	MEAN	SD	K	MAT	N	MEAN	MEAN	SD	K	MAT
120	1	125	100	-	5.12	0	-	-	-	-	-	-	1	125	100	-	5.12	0
150	-	-	-	-	-	-	-	-	-	-	-	-	1	155	75	-	2.01	0
160	1	168	50	-	1.05	0	1	166	200	-	4.37	100	2	167	125	106	2.71	50
170	1	178	50	-	0.89	-	-	-	-	-	-	-	3	177	50	0	0.90	0
180	1	188	75	-	1.13	-	1	182	75	-	1.24	100	3	185	75	0	1.18	50
190	2	196	88	18	1.17	0	-	-	-	-	-	-	4	195	81	13	1.10	0
200	1	208	250	-	2.78	0	5	206	115	34	1.32	20	11	204	141	62	1.67	9
210	1	215	100	-	1.01	0	-	-	-	-	-	-	4	213	100	0	1.04	0
220	1	224	100	-	0.89	-	2	221	100	0	0.93	50	6	223	113	21	1.01	20
230	3	234	142	14	1.10	50	1	230	150	-	1.23	100	15	234	154	21	1.21	14
240	6	244	158	20	1.09	50	2	247	175	35	1.17	100	18	244	163	18	1.12	20
250	10	254	195	26	1.19	20	3	253	183	14	1.14	0	23	254	191	19	1.17	6
260	17	263	209	18	1.15	36	11	263	191	54	1.05	83	37	263	207	35	1.13	35
270	20	274	230	24	1.12	40	9	274	236	18	1.15	67	47	274	234	24	1.14	24
280	26	283	270	25	1.19	58	14	284	263	24	1.15	44	56	284	266	29	1.17	30
290	30	294	296	33	1.16	29	17	295	296	22	1.15	82	69	294	291	30	1.15	29
300	27	304	329	44	1.17	36	41	305	335	64	1.18	66	78	304	329	58	1.17	45
310	39	313	359	42	1.17	40	39	315	351	34	1.13	67	80	314	354	38	1.14	52
320	62	324	398	36	1.17	55	37	324	380	32	1.11	86	108	324	391	35	1.15	57
330	63	333	433	48	1.17	68	40	335	419	44	1.12	96	108	334	428	46	1.15	73
340	75	344	468	43	1.15	61	48	344	470	43	1.15	87	124	344	469	42	1.15	70
350	86	354	504	40	1.14	72	52	354	502	43	1.13	94	141	354	503	41	1.14	79
360	60	364	540	51	1.12	59	71	363	541	56	1.13	89	133	363	540	54	1.12	77
370	49	374	580	55	1.11	73	46	374	583	35	1.11	97	95	374	581	46	1.11	87
380	36	384	646	39	1.14	100	41	384	652	42	1.15	97	77	384	649	41	1.15	98
390	23	394	655	54	1.07	100	26	394	680	48	1.11	100	49	394	668	52	1.10	100
400	8	403	684	109	1.04	86	16	405	725	38	1.09	100	24	404	711	70	1.08	95
410	6	415	783	66	1.09	100	7	413	782	49	1.11	100	13	414	783	55	1.10	100
420	4	423	825	68	1.09	100	6	425	833	63	1.09	100	10	424	830	61	1.09	100
430	3	432	858	128	1.06	100	2	435	825	35	1.01	100	5	433	845	94	1.04	100
440	2	447	938	53	1.05	100	4	444	944	66	1.08	100	6	445	942	56	1.07	100
450	4	456	1050	108	1.11	100	2	456	975	106	1.03	100	6	456	1025	104	1.08	100
460	5	466	1075	64	1.06	100	5	464	1070	69	1.07	100	10	465	1073	63	1.07	100
470	5	474	1190	74	1.12	100	1	475	1275	-	1.19	100	6	474	1204	75	1.13	100
480	8	484	1206	108	1.07	100	2	487	1288	18	1.11	100	10	484	1223	102	1.08	100
490	4	494	1269	47	1.05	100	3	497	1333	95	1.09	100	7	495	1296	73	1.07	100
500	-	-	-	-	-	-	1	500	1350	-	1.08	100	1	500	1350	-	1.08	100
510	1	513	1550	-	1.15	100	1	518	1525	-	1.10	100	2	516	1538	18	1.12	100
520	1	520	1300	-	0.92	100	1	525	1350	-	0.93	100	2	523	1325	35	0.93	100
530	1	530	1600	-	1.07	100	1	532	1600	-	1.06	100	2	531	1600	0	1.07	100
560	-	-	-	-	-	-	1	564	1675	-	0.93	100	1	564	1675	-	0.93	100
TOTAL	693						560						1398					
MEAN		342	481	212	1.15			348	503	213	1.14			337	466	217	1.15	

Table 12. Biological data by age group for walleye caught in experimental gillnets, Kakisa Lake, 1978.

AGE (YR)	MALES N	MALES LENGTH(MM) MEAN	MALES LENGTH(MM) SD	MALES WEIGHT(G) MEAN	MALES WEIGHT(G) SD	MALES K	MALES % MAT	FEMALES N	FEMALES LENGTH(MM) MEAN	FEMALES LENGTH(MM) SD	FEMALES WEIGHT(G) MEAN	FEMALES WEIGHT(G) SD	FEMALES K	FEMALES % MAT	COMBINED N	COMBINED LENGTH(MM) MEAN	COMBINED LENGTH(MM) SD	COMBINED WEIGHT(G) MEAN	COMBINED WEIGHT(G) SD	COMBINED K	COMBINED % MAT
4	1	224	-	100	-	0.89	-	3	199	14.7	92	14	1.16	67	13	212	27.2	113	38	1.19	17
5	16	275	28.9	245	90	1.13	40	3	268	41.8	233	115	1.12	33	40	264	26.7	221	73	1.17	15
6	31	290	29.2	290	80	1.19	57	23	297	29.7	307	102	1.13	67	69	291	26.9	286	83	1.15	43
7	63	329	22.9	418	100	1.16	54	47	330	21.2	398	79	1.11	78	125	326	24.7	398	95	1.14	53
8	81	350	22.3	501	97	1.16	62	68	357	21.7	528	100	1.15	93	155	352	23.4	507	102	1.15	72
9	27	368	23.8	576	105	1.14	86	24	379	20.9	619	96	1.13	100	53	372	23.3	593	103	1.14	89
10	4	387	3.3	644	59	1.11	100	7	391	24.7	696	116	1.16	100	11	390	19.3	677	99	1.14	100
11	3	413	19.4	808	170	1.14	100	2	417	41.7	850	212	1.17	100	5	414	25.1	825	162	1.15	100
12	6	446	23.6	942	140	1.06	100	3	452	9.3	1000	50	1.08	100	9	448	19.5	961	117	1.07	100
13	2	469	16.3	1013	88	0.98	100	2	494	9.2	1313	53	1.09	100	4	481	18.0	1163	183	1.04	100
14	3	493	24.1	1242	52	1.04	100	2	513	26.9	1413	265	1.04	100	5	501	24.2	1310	166	1.04	100
15	1	487	-	1200	-	1.04	100	1	498	-	1400	-	1.13	100	2	493	7.8	1300	141	1.09	100
16	5	487	27.2	1325	177	1.15	100	2	541	32.5	1600	106	1.02	100	7	503	36.9	1404	202	1.11	100
TOTAL	243							187							498						
MEAN		343	52	493	232	1.15			351	53.3	519	249	1.13			337	56.8	469	242	1.15	
MEAN AGE		7.9							7.9							7.6					

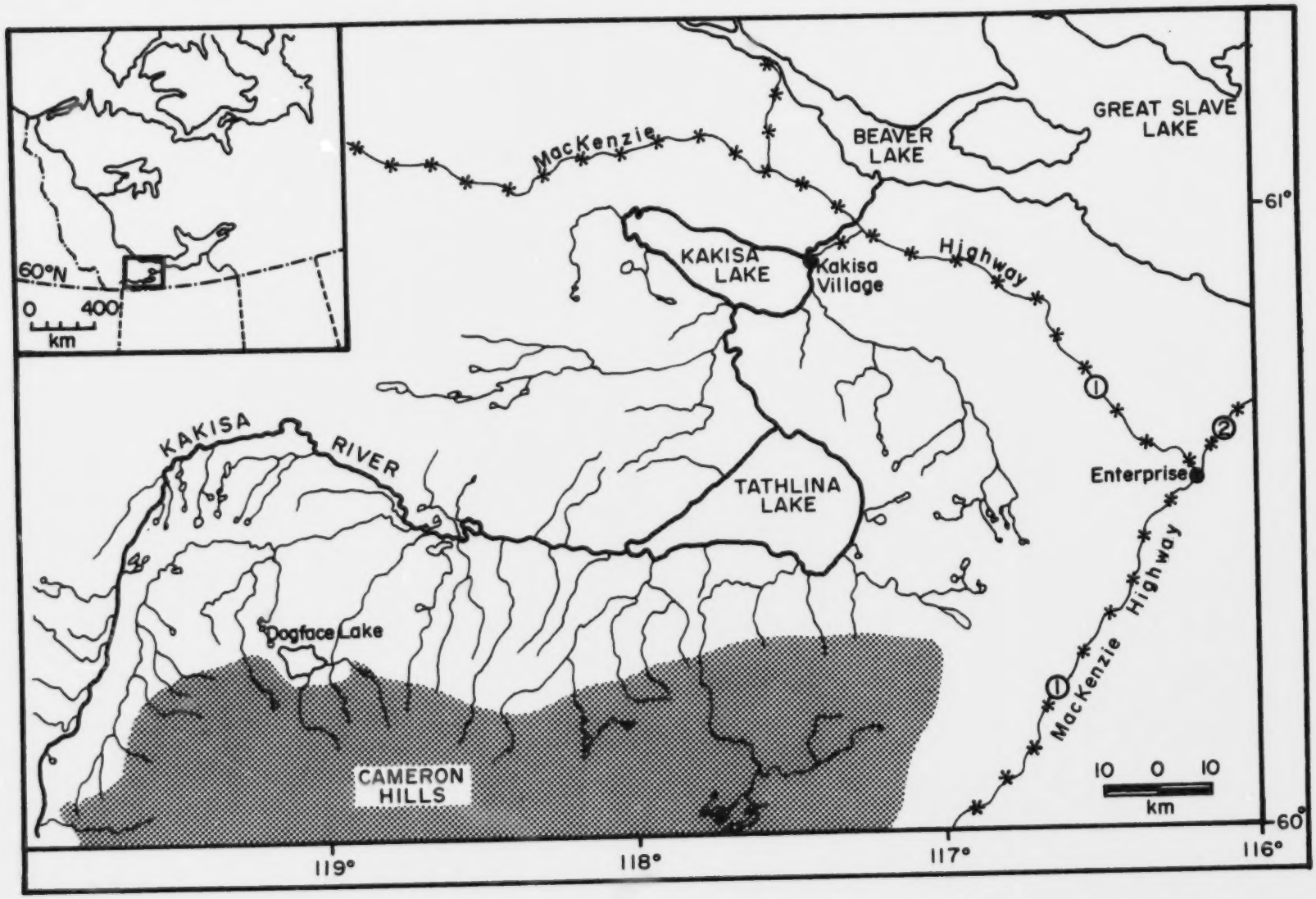

Fig. 1. Map of the southwest portion of the Northwest Territories showing the location of Kakisa Lake.

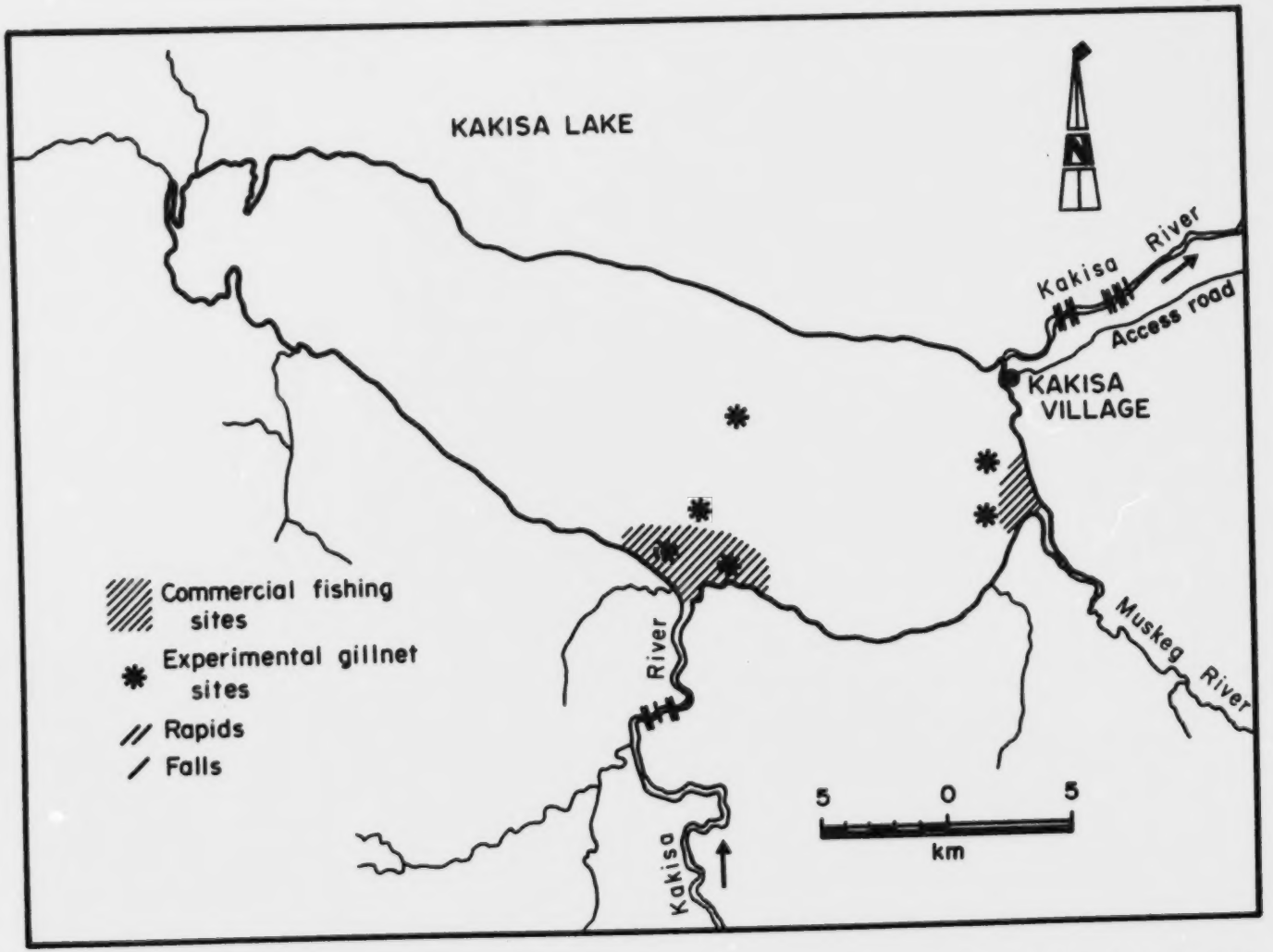

Fig. 2. Map of Kakisa Lake depicting the commercial fishing areas (1977-85) and the location of the experimental gillnet sites.

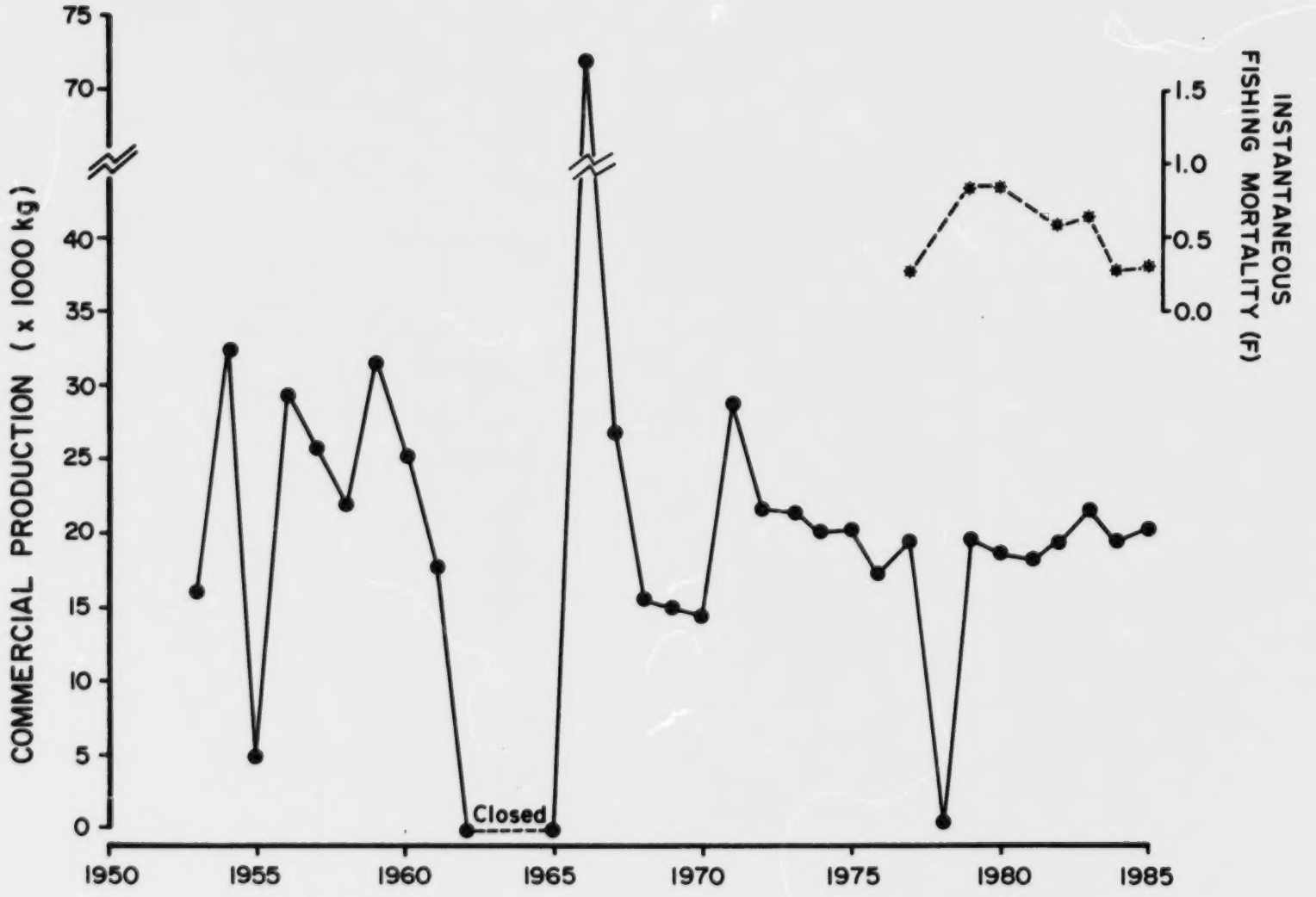

Fig. 3. Commercial production and instantaneous fishing mortality of walleye from Kakisa Lake, 1953-85.

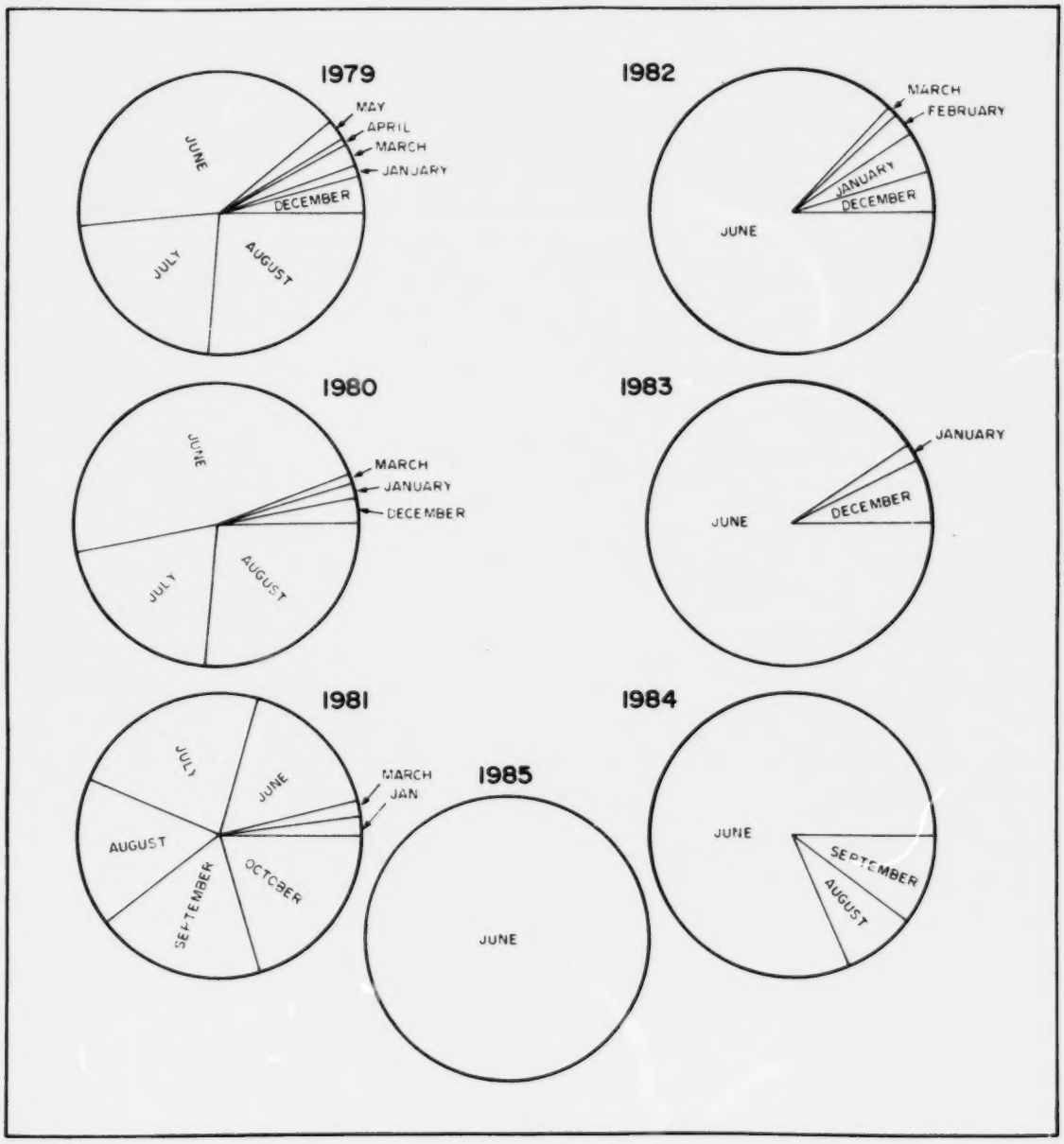

Fig. 4. Monthly percent occurrence of annual commercial harvest from Kakisa Lake, 1979-85.

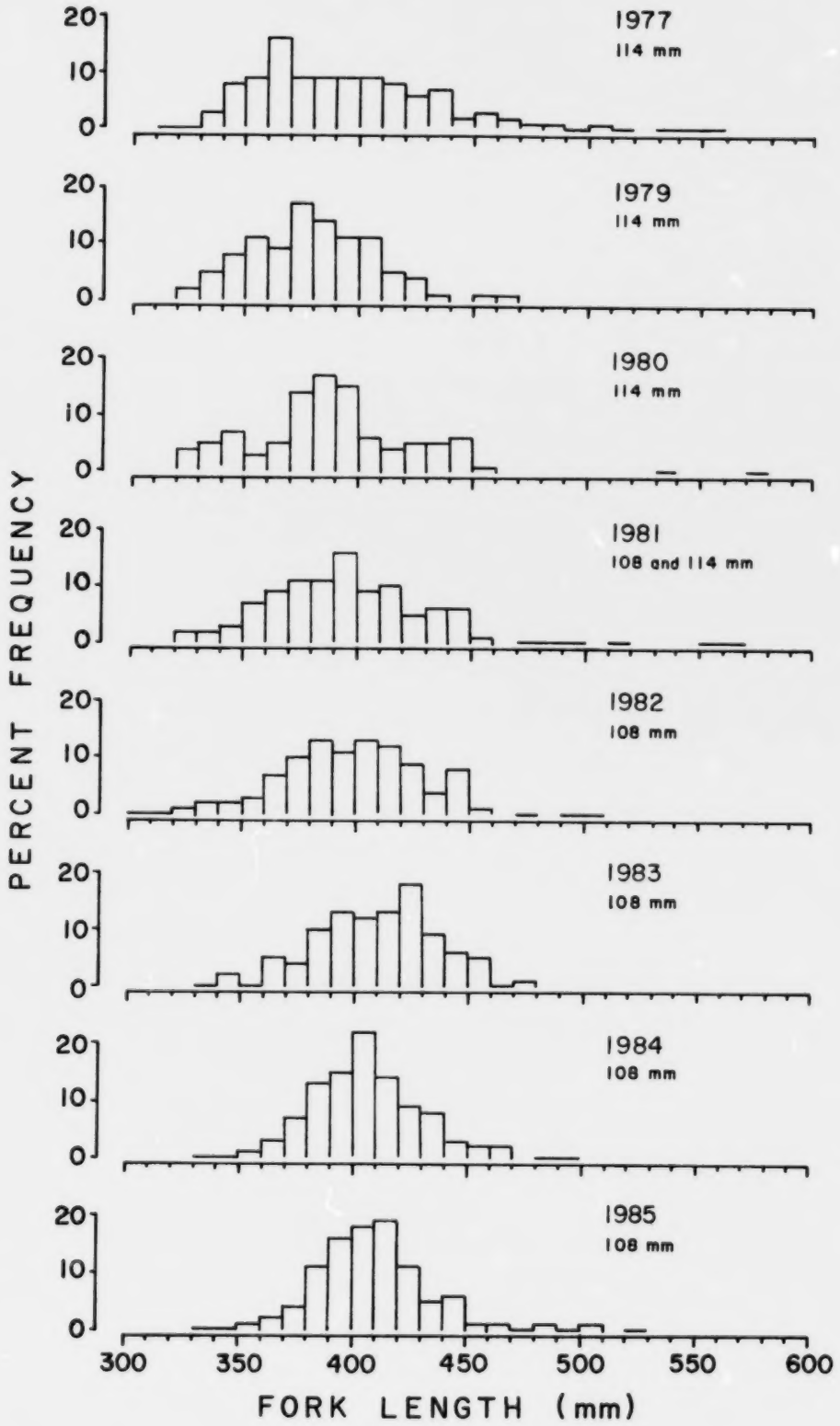

Fig. 5. Length-frequency histograms for walleye caught in the commercial fishery, Kakisa Lake, 1977-85.

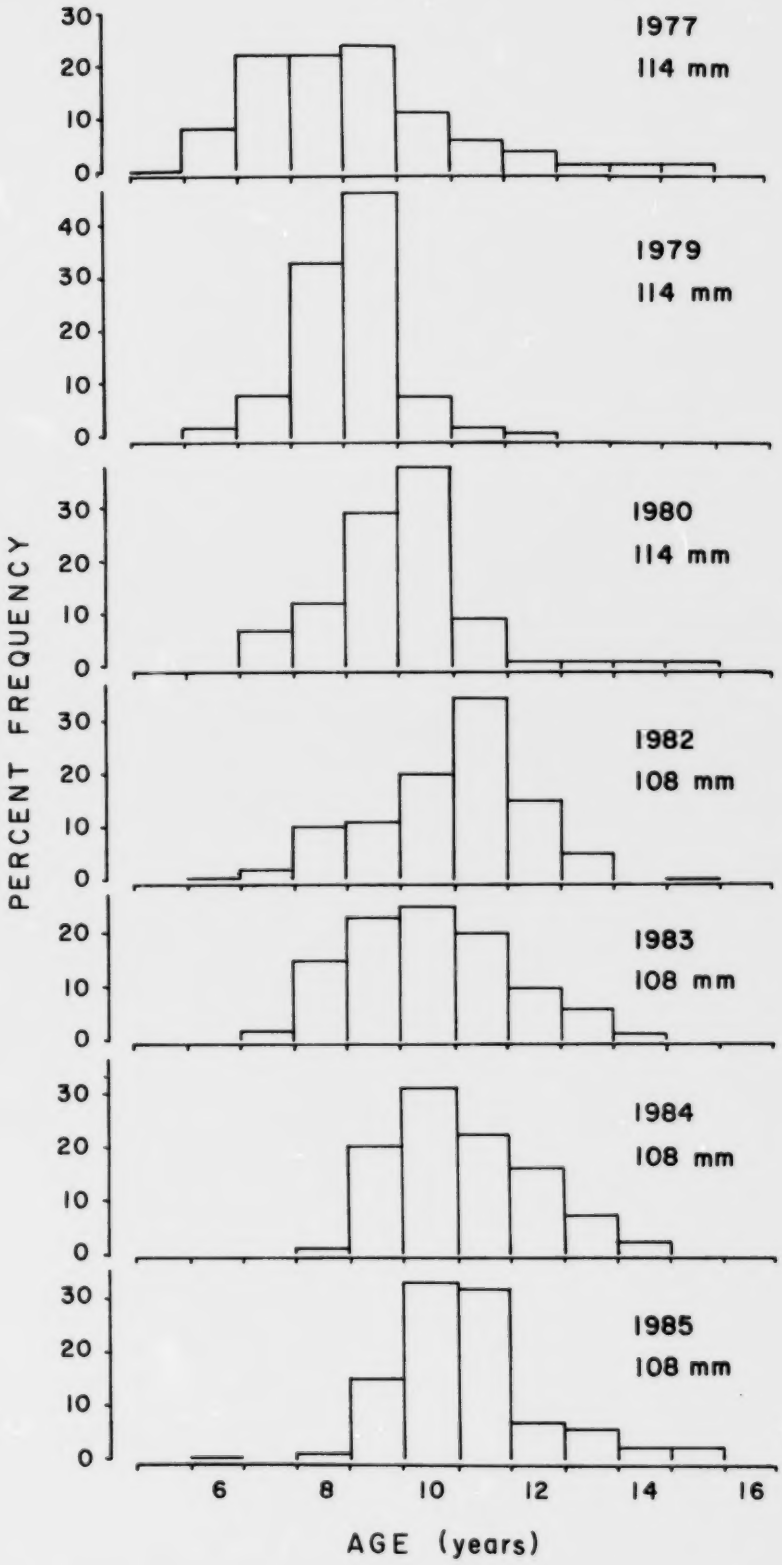

Fig. 6. Age-frequency histograms for walleye caught in the commercial fishery, Kakisa Lake, 1977-85.

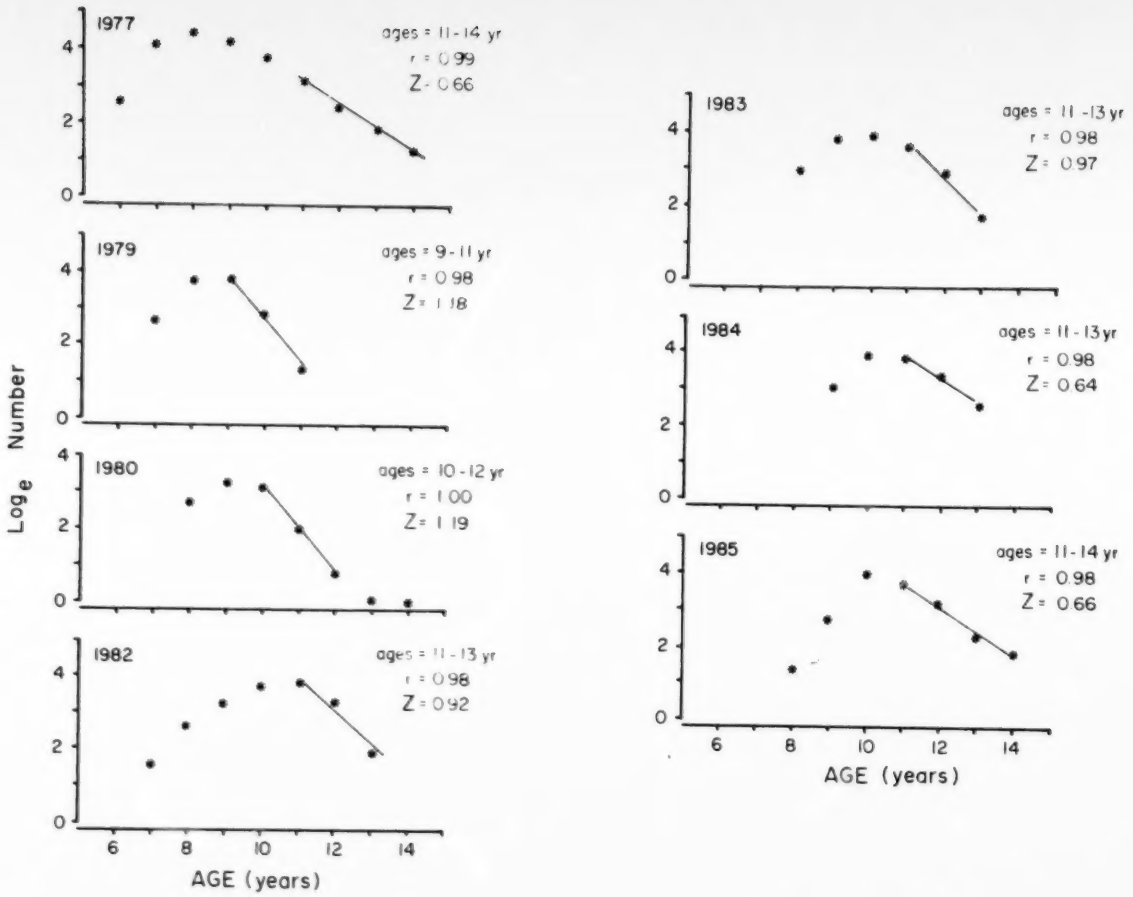

Fig. 7. Catch curves for walleye caught in the commercial fishery, Kakisa Lake, 1977-85.

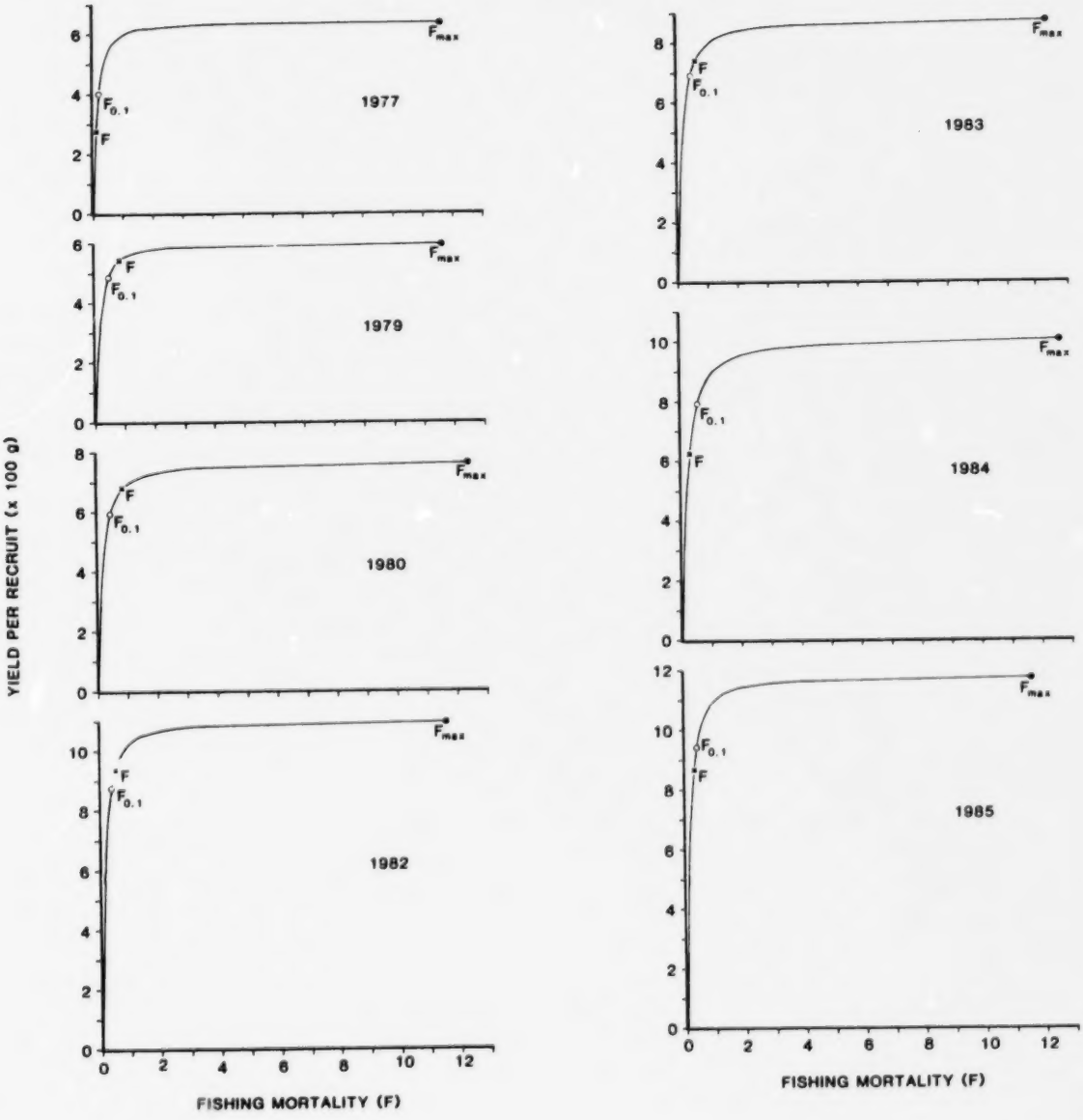

Fig. 8. Yield per recruit curves, depicting present rate of fishing, $F_{0.1}$ and F_{max}, for walleye from Kakisa Lake, 1977-85.

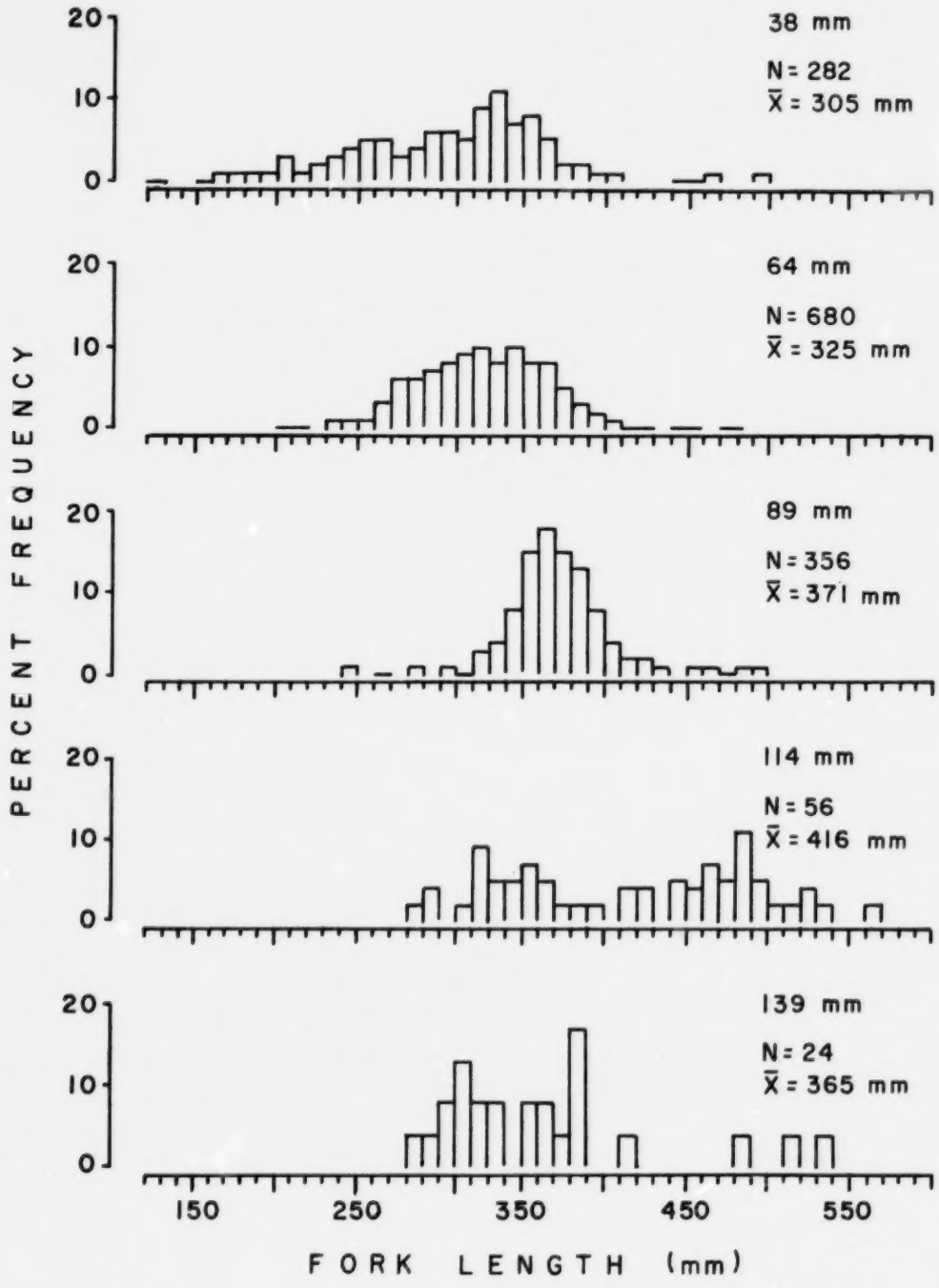

Fig. 9. Length-frequency histograms for walleye caught in experimental gillnets, by mesh size, from Kakisa Lake, 1978.

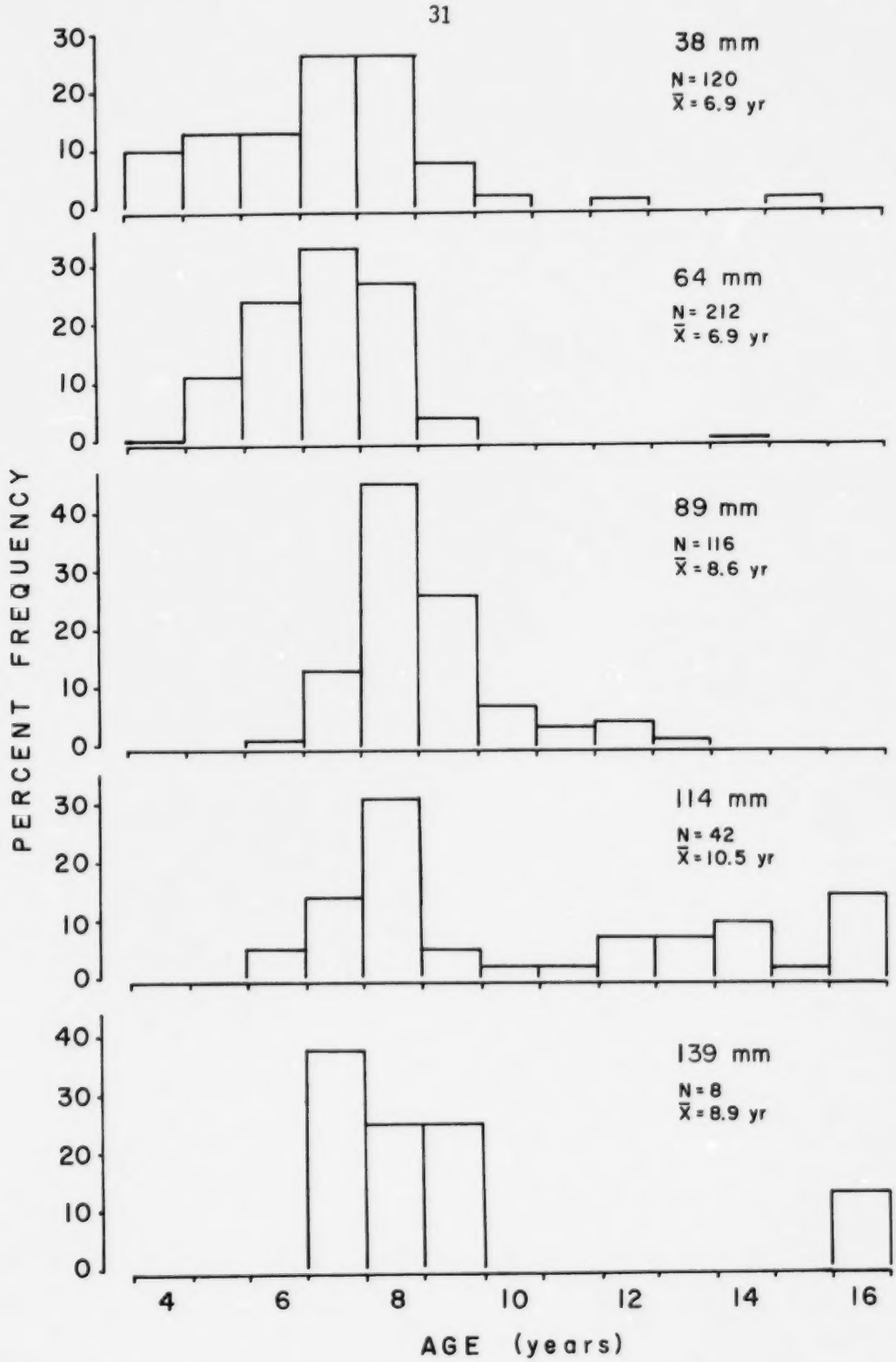

Fig. 10. Age-frequency histograms for walleye caught in experimental gillnets, by mesh size, from Kakisa Lake, 1978.

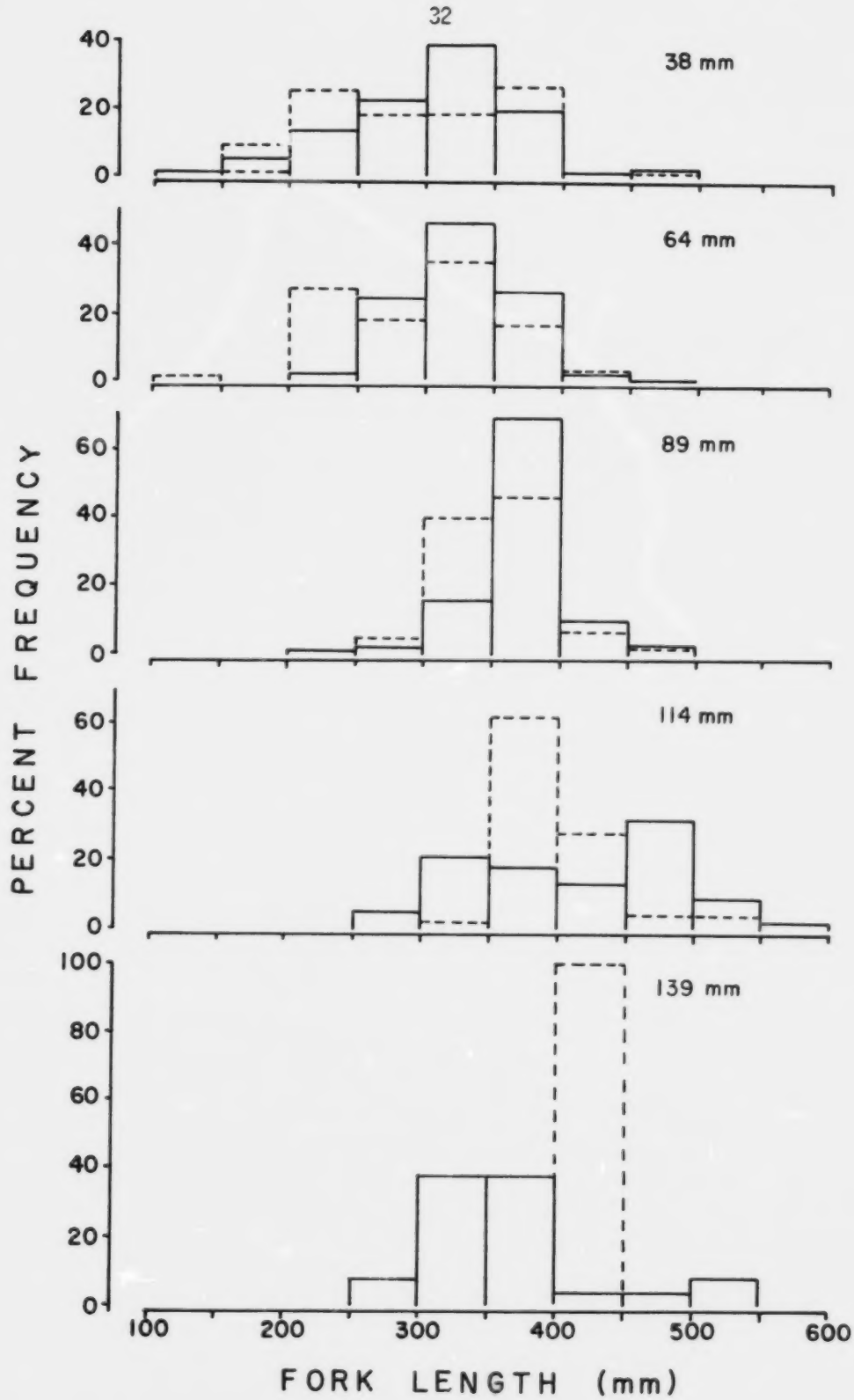

Fig. 11. Comparison of length-frequency histograms for walleye caught in experimental gillnets, by mesh size, from Kakisa Lake, 1968 (---) and 1978 (—).

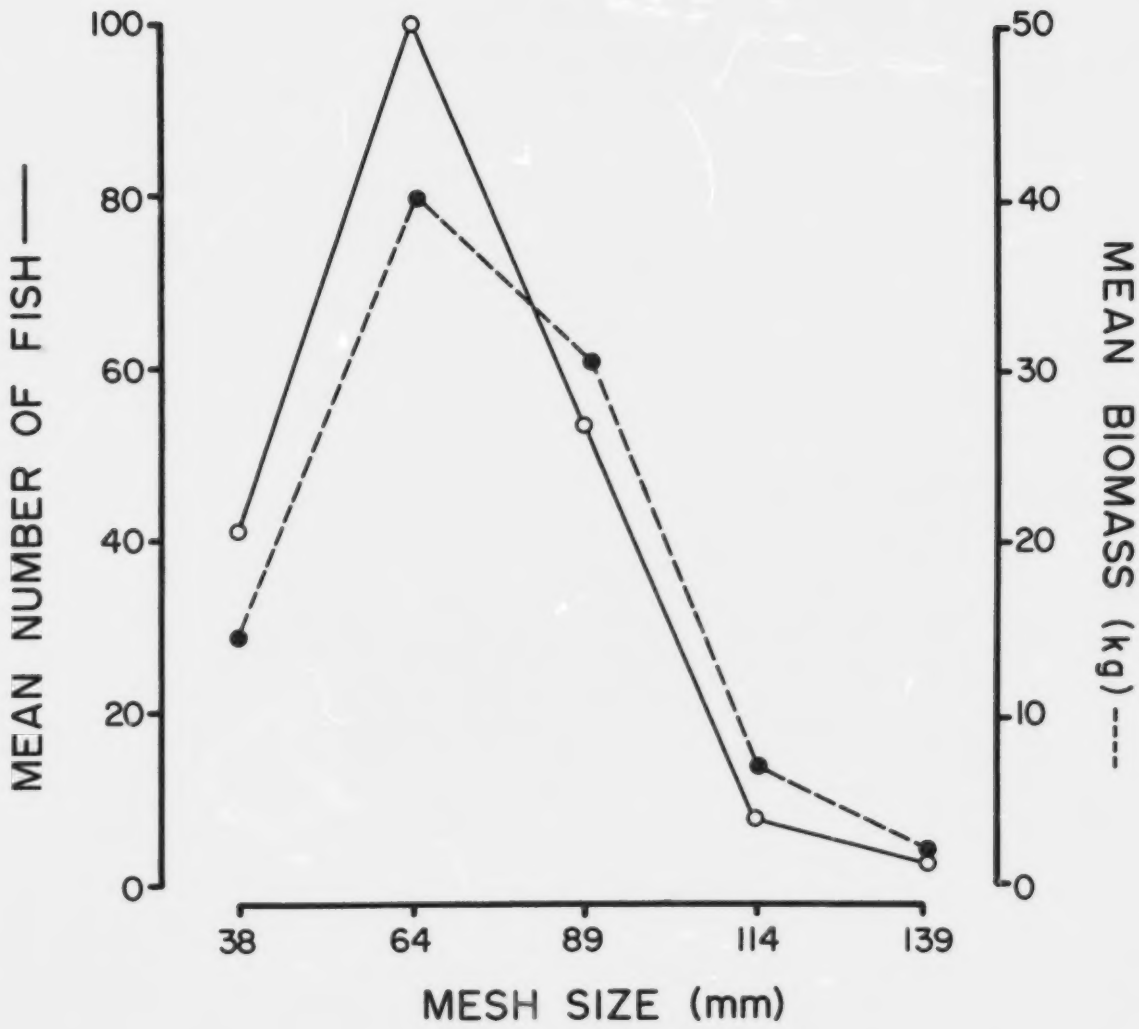

Fig. 12. Mean number of fish and biomass of walleye caught in experimental gillnets, by mesh size, from Kakisa Lake, 1978.

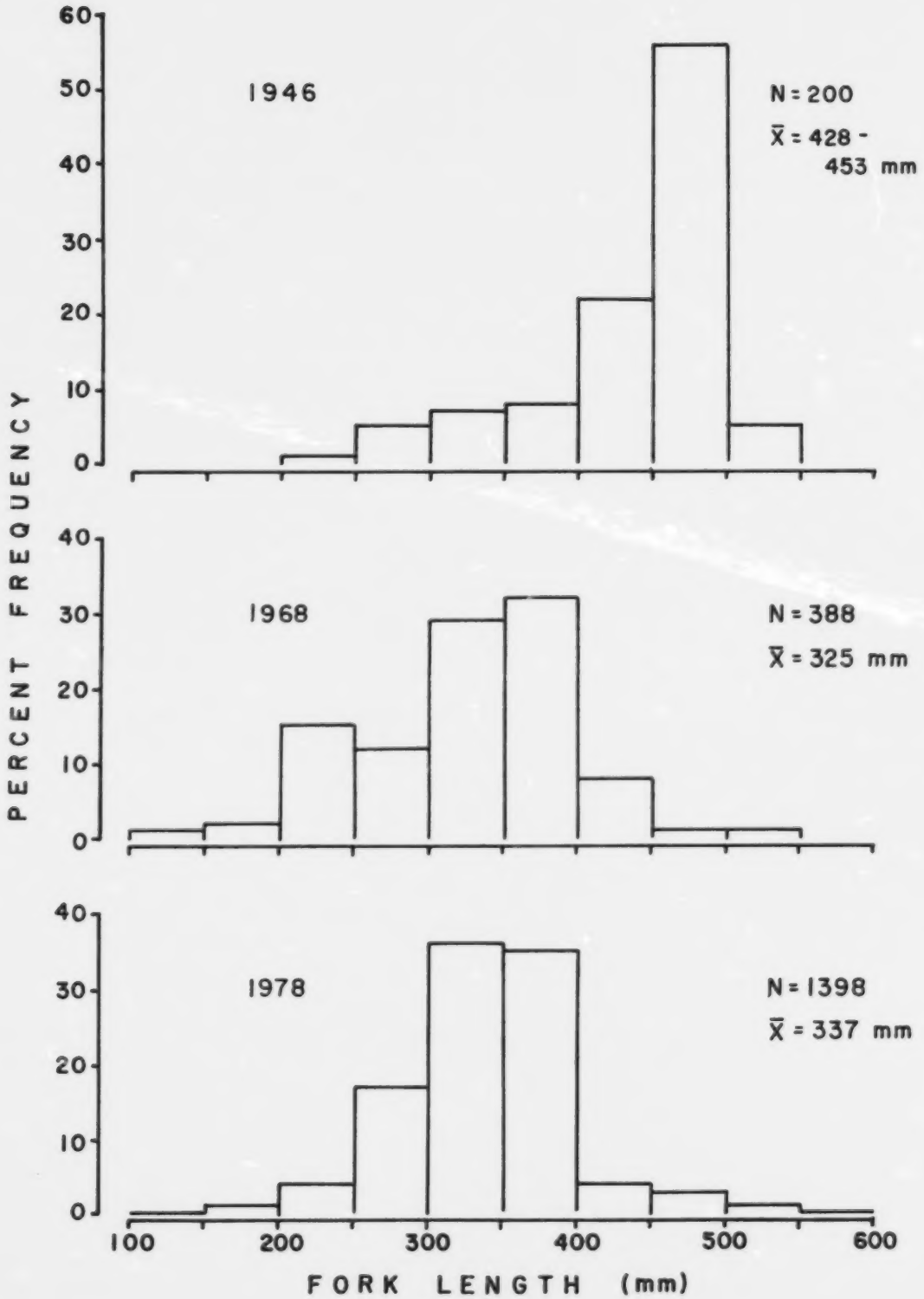

Fig. 13. Comparison of length-frequency histograms for walleye from Kakisa Lake, 1946, 1968 and 1978.

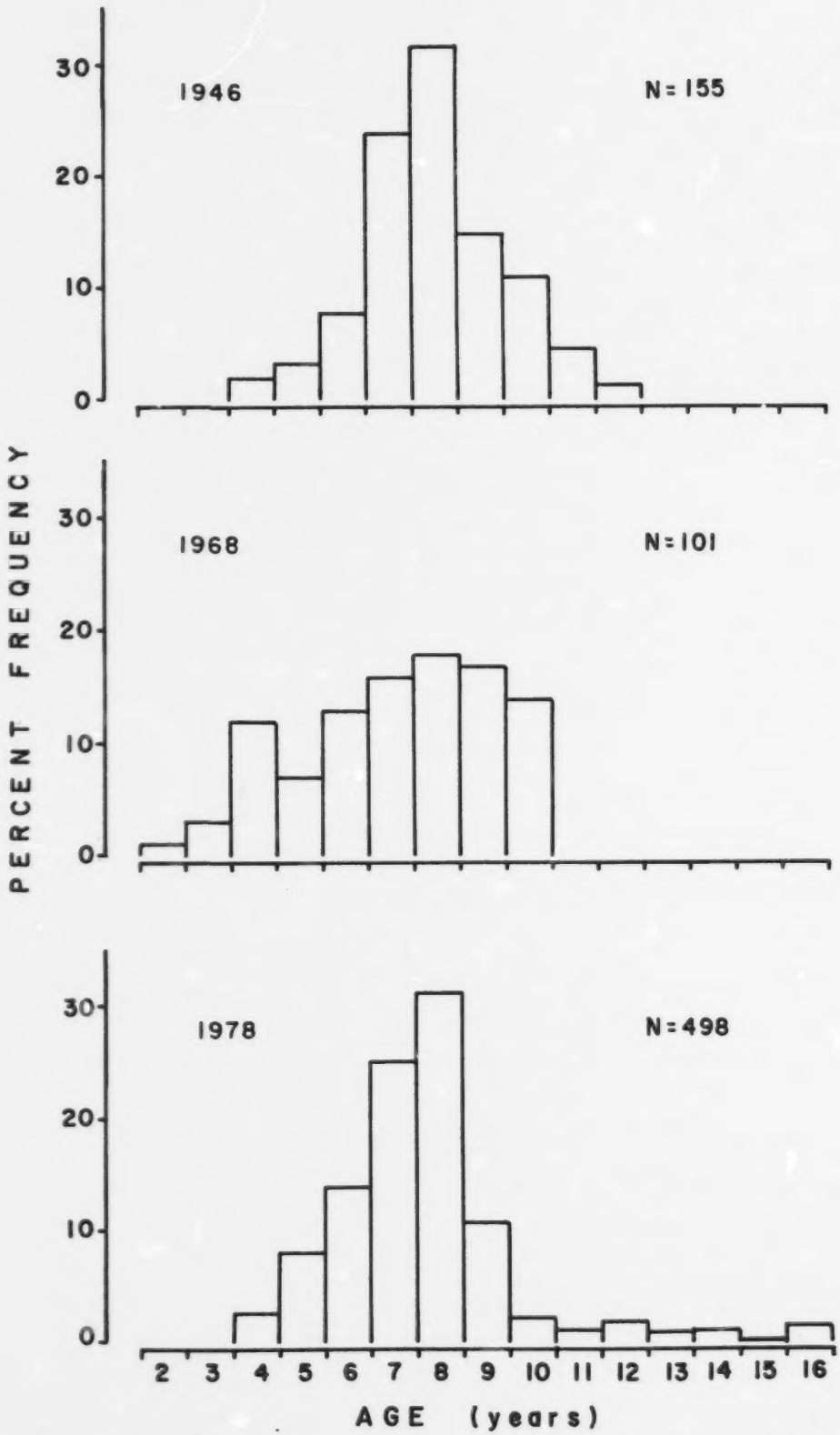

Fig. 14. Comparison of age-frequency histograms for walleye from Kakisa Lake, 1946, 1968 and 1978.

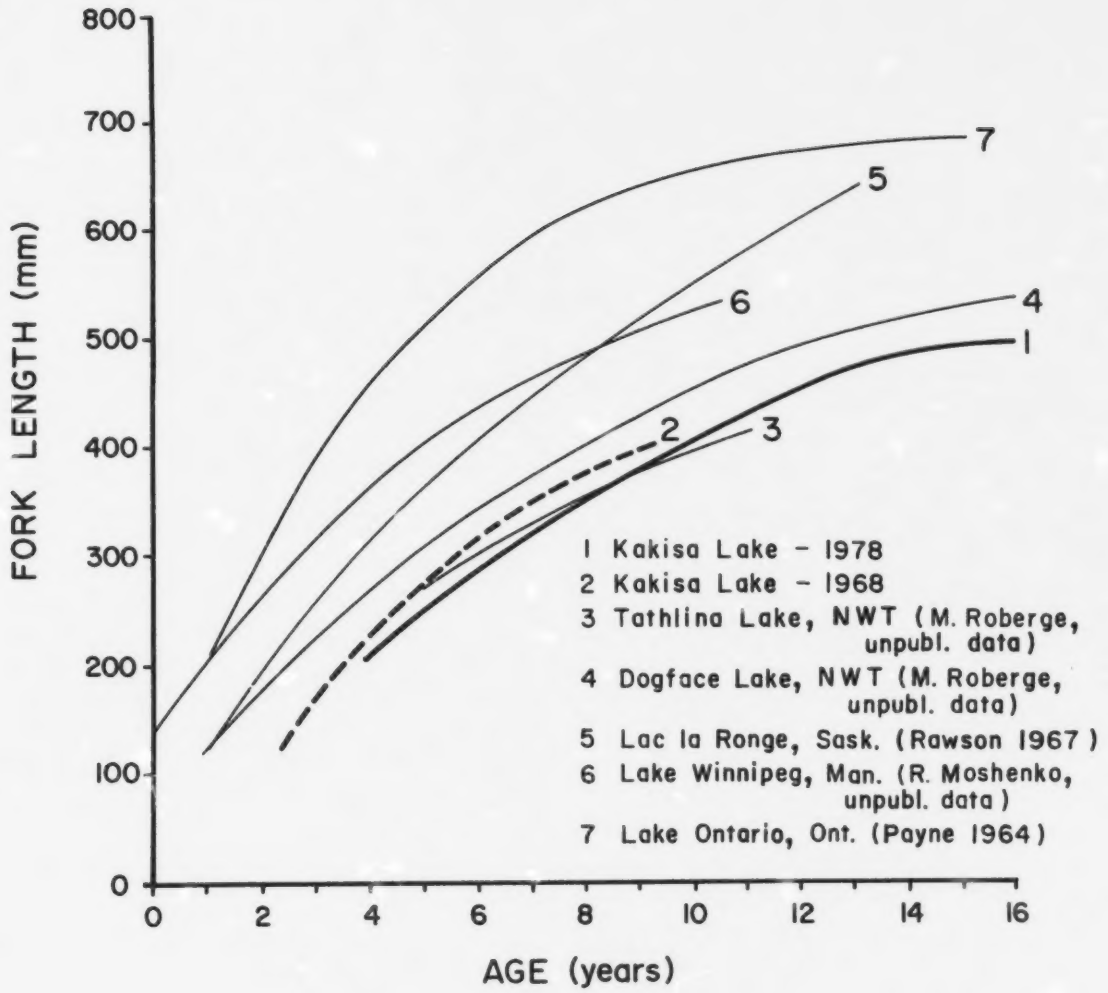

Fig. 15. Age-length relationship for walleye from Kakisa Lake, 1978 compared with other walleye populations.

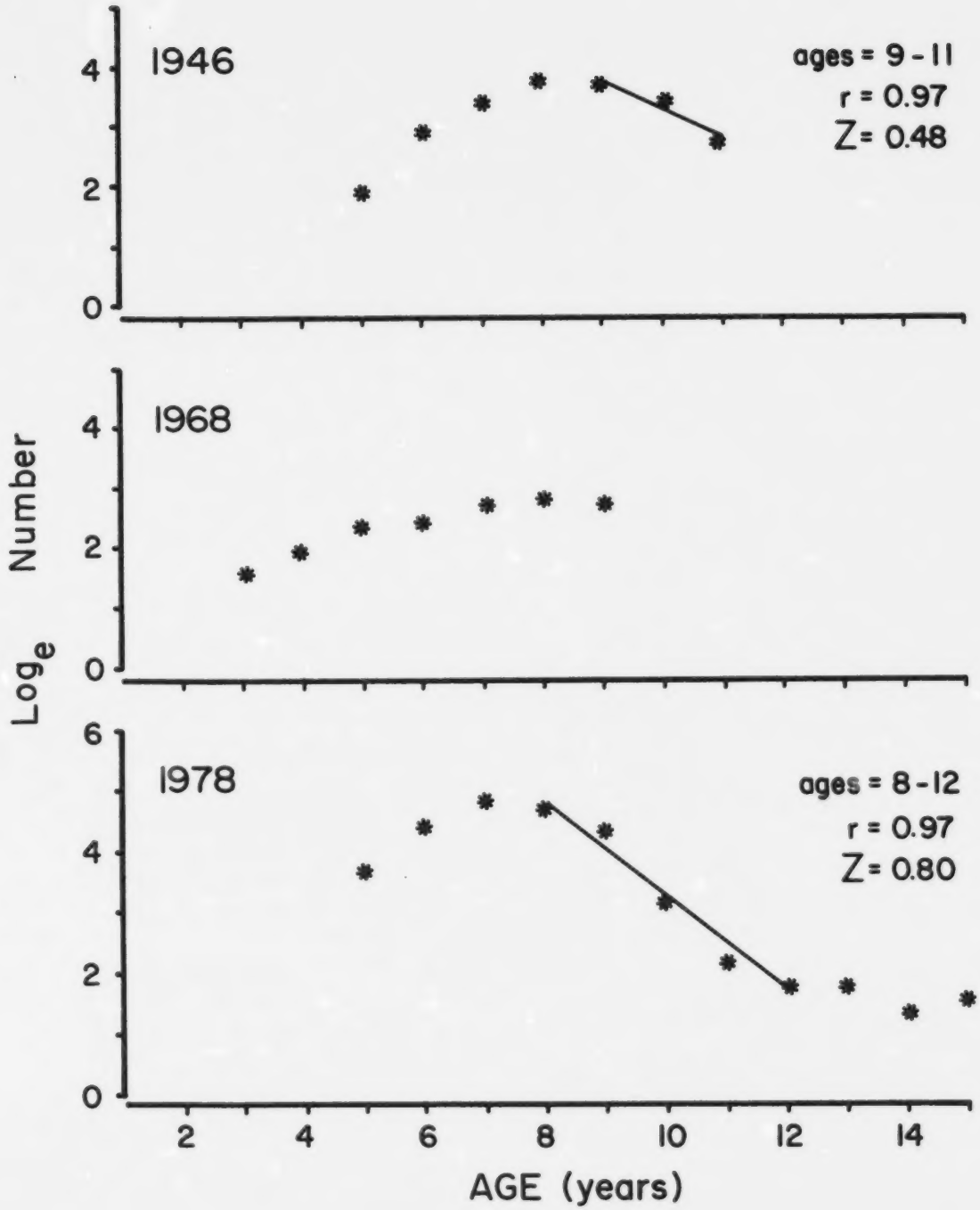

Fig. 16. Catch curves for walleye caught in experimental gillnets from Kakisa Lake, 1946, 1968 and 1978.

Appendix 1. Length, mesh depth, net depth and twine size of each mesh size composing the experimental gillnet gang.

Mesh Size (mm)	Length (m)	Meshes Deep	Approx. Net Depth (m)	Twine Size
38	45.7	60	1.9	210/2
64	45.7	36	1.9	210/2
89	45.7	24	1.8	210/3
114	45.7	20	1.9	210/3
139	45.7	16	1.9	210/3

Appendix 2. A description of the relative stages of maturity used for northern fish in 1972-78 and 1979 on.

1972-78[1]			1979 on[1]		
Sex		Maturity	Maturity		
F	M	Stage	Stage	Female	Male
1	6	Immature - virgin fish, gonad thin and threadlike, often incomplete	Immature	1 - ovaries granular in texture, up to full length in body cavity, hard and triangular in shape, firm membrane; eggs distinguishable	6 - testes puttylike firmness, tubular and scalloped in in shape, long and thin, and may be full length in body cavity
2	7	Maturing - virgin or non-virgin fish not spawning in current year, gonad full length, firm, egtgs of small size, gonads partially filling body cavity	Mature	2 - current year's spawner; ovaries fill body cavity; eggs nearing full size but not loose	7 - current year's spawner; testes large and lobate; white-purplish in colour; milt not expelled by pressure
3	8	Mature - fish spawning in current year, gonad full size filling body cavity, eggs prominent, full size	Ripe	3 - ovaries greatly extended, fill body cavity; eggs full size; eggs expelled by slight pressure	8 - testes full size; white and lobate; milt expelled by slight pressure
4	9	Ripe - mature fish in spawning condition, eggs translucent, milt or eggs expelled under slight pressure	Spent	4 - spawning complete; ovaries flaccid; seed eggs apparent; presence of residual mature eggs	9 - testes flaccid with some milt, blood vessels obvious with pink-violet coloration
5	10	Spent - mature fish completed spawning, gonads collapsed with ruptured blood vessels prominent	Resting	5 - non-virgin; not spawning in current year	10 - non-virgin; not spawning in current year

[1]Fish of unknown sex were coded as 0.

Appendix 3. Percent agreement of ages determined by using scales and dorsal fins for walleye from Kakisa Lake, 1978.

	Age (yr)	
	Scales	Fins
No.	93	95
Mean age	8.0	8.4
S.D.	4.33	4.78

Age difference		
±0 yr	-	39%
±1 yr	-	46%
±2 yr	-	11%
±3 yr	-	1%
±4 yr	-	1%

Appendix 4. Biological data by length interval for walleye caught in the commercial fishery, Kakisa Lake, 1977.

LENGTH INTERVAL (MM)	NO.	PERCENT	MEAN FORK LENGTH(MM)	ROUND WEIGHT(G) MEAN	ROUND WEIGHT(G) SD
310	1	0	314	750	-
320	2	0	326	500	71
330	16	3	335	469	25
340	39	8	345	491	40
350	41	9	354	531	46
360	52	11	363	564	53
370	43	9	374	600	45
380	41	9	384	651	61
390	40	9	395	724	85
400	40	9	404	769	60
410	35	8	414	841	87
420	26	6	424	850	73
430	31	7	433	956	50
440	11	2	443	991	49
450	14	3	454	1000	180
460	9	2	465	1150	79
470	5	1	474	1150	127
480	3	1	486	1300	150
490	2	0	496	1450	141
500	5	1	504	1420	45
510	1	0	518	1450	-
530	1	0	539	1700	-
540	1	0	543	1550	-
550	1	0	555	1900	-
TOTAL	460				
MEAN			393	727	229

Appendix 5. Biological data by length interval for walleye caught in the commercial fishery, Kakisa Lake, 1979.

LENGTH INTERVAL (MM)	NO.	PERCENT	MEAN FORK LENGTH(MM)	ROUND WEIGHT(G) MEAN	ROUND WEIGHT(G) SD
320	4	2	326	537	65
330	9	5	336	622	72
340	16	8	344	665	52
350	22	11	354	689	58
360	18	9	365	771	54
370	33	17	374	798	63
380	28	14	384	874	52
390	22	11	393	906	83
400	21	11	404	1014	70
410	10	5	411	1042	56
420	8	4	423	1113	73
430	1	1	430	1220	-
450	2	1	454	1316	49
460	2	1	462	1354	17
TOTAL	196				
MEAN			378	844	169

Appendix 6. Biological data by length interval for walleye caught in the commercial fishery, Kakisa Lake, 1980.

LENGTH INTERVAL (MM)	NO.	PERCENT	MEAN FORK LENGTH(MM)	ROUND WEIGHT(G) MEAN	ROUND WEIGHT(G) SD
320	4	4	325	503	30
330	6	5	333	539	46
340	8	7	345	579	33
350	3	3	354	610	0
360	6	5	363	681	25
370	15	14	375	732	40
380	19	17	385	777	49
390	17	15	394	843	66
400	7	6	404	906	55
410	4	4	412	945	35
420	6	5	425	1078	114
430	6	5	434	1098	67
440	7	6	442	1185	99
450	1	1	450	1281	-
530	1	1	532	1891	-
570	1	1	572	2257	-
TOTAL	111				
MEAN			389	836	259

Appendix 7. Biological data by length interval for walleye caught in the commercial fishery, Kakisa Lake, 1981.

LENGTH INTERVAL (MM)	NO.	PERCENT	MEAN FORK LENGTH(MM)	ROUND WEIGHT(G) MEAN	ROUND WEIGHT(G) SD
320	4	2	326	527	37
330	4	2	333	503	62
340	6	3	346	583	0
350	14	7	357	666	55
360	19	9	367	722	65
370	24	11	375	756	72
380	24	11	385	809	64
390	35	16	395	797	154
400	19	9	405	903	114
410	21	10	414	914	63
420	10	5	424	976	116
430	12	6	435	1035	67
440	12	6	446	1059	166
450	3	1	456	1053	43
470	1	0	471	1103	-
480	1	0	486	1325	-
490	1	0	492	731	-
510	1	0	519	1548	-
550	1	0	560	954	-
560	1	0	566	954	-
TOTAL	213				
MEAN			396	832	175

Appendix 8. Biological data by length interval for walleye caught in the commercial fishery, Kakisa Lake, 1982.

LENGTH INTERVAL (MM)	NO.	PERCENT	MEAN FORK LENGTH(MM)	ROUND WEIGHT(G) MEAN	SD
300	1	0	308	806	-
310	1	0	314	509	-
320	3	1	325	459	43
330	4	2	336	527	71
340	5	2	345	598	33
350	7	3	357	657	96
360	15	7	366	721	62
370	22	10	375	758	59
380	28	13	386	837	106
390	23	11	395	861	75
400	28	13	404	904	64
410	25	12	414	948	93
420	18	9	423	954	57
430	8	4	434	991	69
440	16	8	444	1093	85
450	3	1	456	1226	113
460	1	0	461	1103	-
480	1	0	483	1251	-
490	1	0	498	1474	-
TOTAL	210				
MEAN			398	868	166

Appendix 9. Biological data by length interval for walleye caught in the commercial fishery, Kakisa Lake, 1983.

LENGTH INTERVAL (MM)	NO.	PERCENT	MEAN FORK LENGTH(MM)	ROUND WEIGHT(G) MEAN	SD
330	1	0	334	400	-
340	4	2	345	463	25
350	1	0	353	500	-
360	10	5	365	625	42
370	8	4	374	650	65
380	22	10	385	706	51
390	28	13	395	786	49
400	26	12	405	808	48
410	27	13	415	869	56
420	38	18	425	907	74
430	19	9	434	961	49
440	13	6	444	1004	63
450	10	5	455	1064	72
460	1	0	460	1100	-
470	2	1	474	1175	35
TOTAL	210				
MEAN			410	838	145

Appendix 10. Biological data by length interval for walleye caught in the commercial fishery, Kakisa Lake, 1984.

LENGTH INTERVAL (MM)	NO.	PERCENT	MEAN FORK LENGTH(MM)	ROUND WEIGHT(G) MEAN	ROUND WEIGHT(G) SD
330	1	0	337	500	-
340	1	0	348	600	-
350	2	1	355	625	106
360	6	3	366	650	55
370	14	7	374	700	55
380	27	13	384	726	45
390	31	15	394	802	43
400	47	22	404	827	49
410	29	14	414	886	63
420	20	9	424	935	40
430	17	8	434	997	72
440	6	3	445	1000	63
450	4	2	454	1088	63
460	4	2	465	1188	95
480	1	0	480	1200	-
490	1	0	494	1550	-
TOTAL	211				
MEAN			405	846	136

Appendix 11. Biological data by length interval for walleye caught in the commercial fishery, Kakisa Lake, 1985.

LENGTH INTERVAL (MM)	NO.	PERCENT	MEAN FORK LENGTH(MM)	ROUND WEIGHT(G) MEAN	ROUND WEIGHT(G) SD
330	1	0	338	427	-
340	1	0	349	671	-
350	3	1	352	590	35
360	5	2	362	671	114
370	8	4	376	701	46
380	24	11	385	729	71
390	33	16	394	784	59
400	38	18	404	833	48
410	39	19	414	877	65
420	24	11	424	940	62
430	11	5	434	959	73
440	12	6	443	1062	55
450	2	1	457	1128	43
460	2	1	465	1128	43
470	1	0	470	1220	-
480	2	1	485	1311	129
490	1	0	497	1220	-
500	2	1	504	1281	173
520	1	0	524	1647	-
TOTAL	210				
MEAN			409	861	153

Appendix 12. Biological data by age group for walleye caught in the commercial fishery, Kakisa Lake, 1977.

AGE (YR)	NO.	PERCENT	FORK LENGTH(MM) MEAN	FORK LENGTH(MM) SD	ROUND WEIGHT(G) MEAN	ROUND WEIGHT(G) SD
5	1	0	365	-	550	-
6	29	8	357	15.9	537	69
7	78	22	360	16.6	547	83
8	78	22	378	23.9	640	136
9	84	24	402	28.1	767	162
10	39	11	424	22.7	862	150
11	21	6	436	23.8	948	171
12	16	4	451	30.3	1041	214
13	4	1	479	60.4	1313	459
14	4	1	507	31.2	1413	269
15	3	1	496	43.5	1283	275
TOTAL	357					
MEAN			393	40.7	723	232
MEAN AGE	8.6					

Appendix 13. Biological data by age group for walleye caught in the commercial fishery, Kakisa Lake, 1979.

AGE (YR)	NO.	PERCENT	FORK LENGTH(MM) MEAN	FORK LENGTH(MM) SD	ROUND WEIGHT(G) MEAN	ROUND WEIGHT(G) SD
6	3	2	357	28.3	720	184
7	15	8	344	11.1	656	86
8	58	33	370	19.5	779	130
9	82	46	386	22.2	895	148
10	14	8	401	19.6	965	146
11	4	2	421	29.7	1083	193
12	1	1	452	-	1351	-
TOTAL	177					
MEAN			379	26.2	846	169
MEAN AGE	8.6					

Appendix 14. Biological data by age group for walleye caught in the commercial fishery, Kakisa Lake, 1980.

AGE (YR)	NO.	PERCENT	FORK LENGTH(MM) MEAN	FORK LENGTH(MM) SD	ROUND WEIGHT(G) MEAN	ROUND WEIGHT(G) SD
7	8	7	334	9.0	541	51
8	13	12	360	26.5	666	137
9	31	29	386	20.5	795	138
10	41	38	399	26.0	884	179
11	10	9	408	26.5	939	200
12	1	1	429	-	1281	-
13	1	1	444	-	1098	-
14	1	1	572	-	2257	-
15	1	1	532	-	1891	-
TOTAL	107					
MEAN			390	38.5	839	260
MEAN AGE	9.5					

Appendix 15. Biological data by age group for walleye caught in the commercial fishery, Kakisa Lake, 1982.

AGE (YR)	NO.	PERCENT	FORK LENGTH(MM) MEAN	FORK LENGTH(MM) SD	ROUND WEIGHT(G) MEAN	ROUND WEIGHT(G) SD
6	1	0	381	-	731	-
7	5	2	350	18.5	538	113
8	21	10	369	25.3	724	117
9	23	11	381	22.1	812	132
10	40	20	397	31.0	885	149
11	68	34	405	28.5	898	157
12	31	15	412	23.0	928	143
13	11	5	420	30.8	988	174
15	1	0	454	-	1251	-
TOTAL	201					
MEAN			398	31.3	869	169
MEAN AGE	10.4					

Appendix 16. Biological data by age group for walleye caught in the commercial fishery, Kakisa Lake, 1983.

AGE (YR)	NO.	PERCENT	FORK LENGTH(MM) MEAN	FORK LENGTH(MM) SD	ROUND WEIGHT(G) MEAN	ROUND WEIGHT(G) SD
7	4	2	370	15	588	95
8	31	15	379	23	682	146
9	47	23	402	21	809	118
10	51	25	416	19	863	100
11	40	20	420	17	853	107
12	21	10	436	18	954	121
13	6	3	440	15	975	88
14	1	0	474	-	1150	-
TOTAL	201					
MEAN			410	27	838	147
MEAN AGE	9.9					

Appendix 17. Biological data by age group for walleye caught in the commercial fishery, Kakisa Lake, 1984.

AGE (YR)	NO.	PERCENT	FORK LENGTH(MM) MEAN	FORK LENGTH(MM) SD	ROUND WEIGHT(G) MEAN	ROUND WEIGHT(G) SD
8	3	1	371	40	632	189
9	42	20	389	18	765	91
10	63	31	397	16	803	89
11	45	22	410	17	866	107
12	33	16	418	17	909	105
13	15	7	435	23	967	119
14	4	2	460	26	1225	240
TOTAL	205					
MEAN			405	24	844	133
MEAN AGE	10.6					

Appendix 18. Biological data by age group for walleye caught in the commercial fishery, Kakisa Lake, 1985.

AGE (YR)	NO.	PERCENT	FORK LENGTH(MM) MEAN	FORK LENGTH(MM) SD	ROUND WEIGHT(G) MEAN	ROUND WEIGHT(G) SD
6	1	0	338	-	427	-
8	2	1	359	3.5	701	129
9	31	15	386	17.6	730	94
10	67	33	404	15.7	829	94
11	65	32	415	19.3	901	116
12	14	7	412	28.5	880	195
13	13	6	424	18.0	915	125
14	4	2	467	41.5	1189	332
15	4	2	483	38.6	1189	176
TOTAL	201					
MEAN			409	26.7	857	153
MEAN AGE	10.6					

Appendix 19. Biological data by length interval for walleye caught by experimental gillnets (38mm mesh), Kakisa Lake, 1978.

LENGTH INTERVAL (MM)	MALES						FEMALES						COMBINED					
		LENGTH(MM)	WEIGHT(G)			%		LENGTH(MM)	WEIGHT(G)			%		LENGTH(MM)	WEIGHT(G)			%
	N	MEAN	MEAN	SD	K	MAT	N	MEAN	MEAN	SD	K	MAT	N	MEAN	MEAN	SD	K	MAT
120	1	125	100	-	5.12	0	-	-	-	-	-	-	1	125	100	-	5.12	0
150	-	-	-	-	-	-	-	-	-	-	-	-	1	155	75	-	2.01	0
160	1	168	50	-	1.05	0	1	166	200	-	4.37	100	2	167	125	106	2.71	50
170	1	178	50	-	0.89	-	-	-	-	-	-	-	3	177	50	0	0.90	0
180	1	188	75	-	1.13	-	1	182	75	-	1.24	100	3	185	75	0	1.18	50
190	2	196	88	18	1.17	0	-	-	-	-	-	-	4	195	81	13	1.10	0
200	-	-	-	-	-	-	4	206	100	0	1.15	25	9	203	125	53	1.51	11
210	1	215	100	-	1.01	0	-	-	-	-	-	-	3	214	100	0	1.02	0
220	1	224	100	-	0.89	-	2	221	100	0	0.93	50	6	223	113	21	1.01	20
230	2	236	150	0	1.14	100	-	-	-	-	-	-	9	234	148	9	1.15	13
240	1	248	150	-	0.98	100	1	245	150	-	1.02	-	11	244	159	13	1.09	10
250	8	253	194	29	1.19	20	-	-	-	-	-	-	13	254	192	24	1.18	10
260	5	263	205	11	1.12	0	6	263	167	63	0.93	50	13	263	192	49	1.06	14
270	3	274	225	25	1.09	0	1	276	250	-	1.19	0	8	274	231	18	1.12	0
280	5	282	250	31	1.11	100	-	-	-	-	-	-	11	283	250	30	1.10	25
290	11	294	286	44	1.12	25	3	294	300	0	1.18	50	16	294	288	38	1.13	25
300	9	302	308	22	1.12	29	8	305	316	23	1.11	50	18	304	304	39	1.09	33
310	9	314	367	28	1.18	40	5	315	340	22	1.09	100	14	314	357	28	1.15	57
320	17	324	404	27	1.19	75	7	324	379	30	1.11	100	24	324	397	30	1.17	80
330	19	333	438	68	1.19	50	12	335	421	26	1.12	100	32	334	430	55	1.16	71
340	12	344	456	61	1.12	60	7	344	482	51	1.19	100	19	344	466	58	1.15	71
350	15	354	503	35	1.13	73	8	352	484	38	1.11	86	23	353	497	36	1.13	78
360	8	365	559	61	1.15	60	6	363	533	44	1.12	83	14	364	548	54	1.14	73
370	3	373	583	29	1.12	100	3	373	567	29	1.09	100	6	373	575	27	1.11	100
380	3	385	692	29	1.21	100	3	385	700	87	1.22	100	6	385	696	58	1.21	100
390	3	391	667	58	1.11	100	1	398	650	-	1.03	100	4	393	663	48	1.09	100
400	2	401	575	212	0.89	50	1	400	750	-	1.17	100	3	401	633	181	0.98	67
440	1	445	975	-	1.11	100	-	-	-	-	-	-	1	445	975	-	1.11	100
450	-	-	-	-	-	-	1	455	1050	-	1.11	100	1	455	1050	-	1.11	100
460	1	460	975	-	1.00	100	1	464	1075	-	1.08	100	2	462	1025	71	1.04	100
490	1	494	1200	-	1.00	100	1	498	1400	-	1.13	100	2	496	1300	141	1.06	100
TOTAL	146						83						282					
MEAN		318	395	178	1.17			323	413	218	1.15			305	358	198	1.17	

Appendix 20. Biological data by length interval for walleye caught by experimental gillnets (64mm mesh), Kakisa Lake, 1978.

LENGTH INTERVAL (MM)	MALES						FEMALES						COMBINED					
		LENGTH(MM)	WEIGHT(G)			%		LENGTH(MM)	WEIGHT(G)			%		LENGTH(MM)	WEIGHT(G)			%
	N	MEAN	MEAN	SD	K	MAT	N	MEAN	MEAN	SD	K	MAT	N	MEAN	MEAN	SD	K	MAT
200	1	208	250	-	2.78	0	1	206	175	-	2.00	0	2	207	213	53	2.39	0
210	-	-	-	-	-	-	-	-	-	-	-	-	1	210	100	-	1.08	0
230	1	230	125	-	1.03	0	1	230	150	-	1.23	100	6	233	163	31	1.29	17
240	3	243	167	29	1.16	50	1	248	200	-	1.31	100	5	243	175	25	1.21	50
250	2	258	200	0	1.16	-	3	253	183	14	1.14	0	10	254	190	13	1.16	0
260	11	263	211	21	1.16	43	5	264	220	21	1.20	100	23	263	215	21	1.18	39
270	17	274	231	24	1.13	44	8	274	234	19	1.14	80	39	274	235	25	1.15	29
280	17	283	278	21	1.22	57	13	283	263	24	1.16	44	39	283	270	28	1.18	32
290	18	294	299	22	1.17	33	12	295	298	25	1.16	100	49	294	292	27	1.15	31
300	17	304	331	37	1.17	33	31	305	342	72	1.21	68	56	305	337	59	1.19	49
310	28	313	356	46	1.16	44	31	315	350	35	1.12	65	61	314	352	41	1.14	53
320	39	324	393	42	1.15	48	25	324	375	27	1.10	86	70	324	386	37	1.13	53
330	29	333	416	23	1.13	68	24	334	414	53	1.11	93	56	334	415	38	1.12	73
340	40	344	460	38	1.13	64	30	343	455	34	1.12	90	71	344	458	36	1.13	73
350	34	354	493	49	1.11	81	22	354	484	43	1.09	100	57	354	489	47	1.10	90
360	2:	363	514	61	1.08	56	29	363	522	63	1.09	83	51	363	517	61	1.08	72
370	15	374	568	73	1.09	100	19	375	582	33	1.11	100	34	374	576	54	1.10	100
380	9	383	642	52	1.14	100	11	383	634	45	1.13	100	20	383	638	47	1.13	100
390	6	395	625	67	1.01	100	9	394	667	40	1.09	100	15	395	650	54	1.06	100
400	1	400	700	-	1.09	-	4	406	744	13	1.11	100	5	405	735	22	1.11	100
410	1	418	775	-	1.06	100	2	413	775	0	1.10	100	3	414	775	0	1.09	100
420	-	-	-	-	-	-	2	425	800	0	1.04	100	2	425	800	0	1.04	100
440	-	-	-	-	-	-	2	444	913	88	1.04	100	2	444	913	88	1.04	100
450	-	-	-	-	-	-	1	456	900	-	0.95	100	1	456	900	-	0.95	100
470	1	473	1200	-	1.13	100	1	475	1275	-	1.19	100	2	474	1238	53	1.16	100
TOTAL	311						287						680					
MEAN		327	409	129	1.14			335	437	151	1.13			325	405	143	1.14	

Appendix 21. Biological data by length interval for walleye caught by experimental gillnets (89mm mesh), Kakisa Lake, 1978.

LENGTH INTERVAL (MM)	MALES						FEMALES						COMBINED					
		LENGTH(MM)	WEIGHT(G)			%		LENGTH(MM)	WEIGHT(G)			%		LENGTH(MM)	WEIGHT(G)			%
	N	MEAN	MEAN	SD	K	MAT	N	MEAN	MEAN	SD	K	MAT	N	MEAN	MEAN	SD	K	MAT
240	2	244	150	0	1.04	0	-	-	-	-	-	-	2	244	150	0	1.04	0
260	1	262	200	-	1.11	100	-	-	-	-	-	-	1	262	200	-	1.11	100
280	3	285	258	14	1.11	33	-	-	-	-	-	-	4	285	275	35	1.19	25
290	-	-	-	-	-	-	1	292	275	-	1.10	0	1	292	275	-	1.10	0
300	1	303	475	-	1.71	100	-	-	-	-	-	-	2	306	388	124	1.37	50
310	-	-	-	-	-	-	1	318	350	-	1.09	0	1	318	350	-	1.09	0
320	3	322	417	14	1.25	100	3	326	408	63	1.18	67	9	324	406	39	1.19	43
330	12	334	471	33	1.27	90	2	334	450	0	1.21	-	15	334	467	31	1.25	82
340	19	345	487	35	1.18	64	10	346	508	41	1.23	83	29	345	494	38	1.20	70
350	33	354	516	29	1.17	67	20	356	530	30	1.18	89	55	354	520	30	1.17	69
360	28	364	555	30	1.15	64	34	364	560	49	1.16	96	63	364	558	41	1.16	85
370	30	374	585	47	1.12	56	23	374	587	38	1.12	100	53	374	586	43	1.12	78
380	24	384	642	33	1.13	100	22	385	651	33	1.15	100	46	384	646	33	1.14	100
390	13	393	660	40	1.09	100	16	393	689	52	1.13	100	29	393	676	49	1.11	100
400	5	404	725	35	1.10	100	11	405	716	42	1.08	100	16	405	719	39	1.09	100
410	3	414	742	38	1.05	100	4	415	806	43	1.13	100	7	414	779	51	1.09	100
420	3	420	792	14	1.07	100	3	425	833	80	1.08	100	6	423	813	56	1.08	100
430	3	432	858	128	1.06	100	2	435	825	35	1.01	100	5	433	845	94	1.04	100
450	2	455	975	35	1.04	100	-	-	-	-	-	-	2	455	975	35	1.04	100
460	1	468	1075	-	1.05	100	3	465	1092	80	1.09	100	4	466	1088	66	1.08	100
470	1	475	1100	-	1.03	100	-	-	-	-	-	-	1	475	1100	-	1.03	100
480	3	485	1242	63	1.09	100	-	-	-	-	-	-	3	485	1242	63	1.09	100
490	1	492	1300	-	1.09	100	1	498	1375	-	1.11	100	2	495	1338	53	1.10	100
TOTAL	191						156						356					
MEAN		369	586	162	1.15			376	617	136	1.15			371	596	153	1.15	

Appendix 22. Biological data by length interval for walleye caught by experimental gillnets (114mm mesh), Kakisa Lake, 1978.

LENGTH INTERVAL (MM)	MALES						FEMALES						COMBINED					
		LENGTH(MM)	WEIGHT(G)			%		LENGTH(MM)	WEIGHT(G)			%		LENGTH(MM)	WEIGHT(G)			%
	N	MEAN	MEAN	SD	K	MAT	N	MEAN	MEAN	SD	K	MAT	N	MEAN	MEAN	SD	K	MAT
280	-	-	-	-	-	-	1	288	250	-	1.05	-	1	288	250	-	1.05	-
290	1	299	350	-	1.31	0	1	295	275	-	1.07	-	2	297	313	53	1.19	0
310	1	319	350	-	1.08	0	-	-	-	-	-	-	1	319	350	-	1.08	0
320	3	324	400	0	1.17	0	2	320	400	35	1.22	100	5	323	400	18	1.19	33
330	2	331	400	0	1.10	0	1	338	425	-	1.10	-	3	333	408	14	1.10	0
340	3	346	483	29	1.16	0	-	-	-	-	-	-	3	346	483	29	1.16	0
350	2	357	525	35	1.16	0	2	351	488	18	1.13	-	4	354	506	31	1.14	0
360	1	360	475	-	1.02	-	2	362	525	35	1.11	-	3	361	508	38	1.08	-
370	1	375	575	-	1.09	-	-	-	-	-	-	-	1	375	575	-	1.09	-
380	-	-	-	-	-	-	1	385	700	-	1.23	100	1	385	700	-	1.23	100
390	1	397	750	-	1.20	-	-	-	-	-	-	-	1	397	750	-	1.20	-
410	2	417	850	71	1.18	100	-	-	-	-	-	-	2	417	850	71	1.18	100
420	1	429	925	-	1.17	100	1	423	900	-	1.19	100	2	426	913	18	1.18	100
440	1	448	900	-	1.00	100	2	444	975	35	1.11	100	3	445	950	50	1.08	100
450	2	458	1125	106	1.18	100	-	-	-	-	-	-	2	458	1125	106	1.18	100
460	3	467	1108	38	1.09	100	1	460	1000	-	1.03	100	4	465	1081	63	1.07	100
470	3	474	1217	76	1.14	100	-	-	-	-	-	-	3	474	1217	76	1.14	100
480	4	484	1219	123	1.08	100	2	487	1288	18	1.11	100	6	485	1242	102	1.09	100
490	2	496	1288	18	1.06	100	1	494	1225	-	1.02	100	3	495	1267	38	1.04	100
500	-	-	-	-	-	-	1	500	1350	-	1.08	100	1	500	1350	-	1.08	100
510	-	-	-	-	-	-	1	518	1525	-	1.10	100	1	518	1525	-	1.10	100
520	1	520	1300	-	0.92	100	1	525	1350	-	0.93	100	2	523	1325	35	0.93	100
530	-	-	-	-	-	-	1	532	1600	-	1.06	100	1	532	1600	-	1.06	100
560	-	-	-	-	-	-	1	564	1675	-	0.93	100	1	564	1675	-	0.93	100
TOTAL	34						22						56					
MEAN		413	838	362	1.12			420	892	464	1.10			416	859	402	1.11	

Appendix 23. Biological data by length interval for walleye caught by experimental gillnets (139mm mesh), Kakisa Lake, 1978.

LENGTH INTERVAL (MM)	MALES						FEMALES						COMBINED					
		LENGTH(MM)	WEIGHT(G)			%		LENGTH(MM)	WEIGHT(G)			%		LENGTH(MM)	WEIGHT(G)			%
	N	MEAN	MEAN	SD	K	MAT	N	MEAN	MEAN	SD	K	MAT	N	MEAN	MEAN	SD	K	MAT
280	1	287	275	-	1.16	-	-	-	-	-	-	-	1	287	275	-	1.16	-
290	-	-	-	-	-	-	-	-	-	-	-	-	1	294	275	-	1.08	-
300	-	-	-	-	-	-	2	305	300	0	1.06	-	2	305	300	0	1.06	-
310	1	312	375	-	1.23	0	2	317	400	0	1.26	100	3	315	392	14	1.25	50
330	1	332	475	-	1.30	-	1	338	450	-	1.17	-	2	335	463	18	1.23	-
340	1	344	500	-	1.23	-	1	340	450	-	1.14	0	2	342	475	35	1.19	0
350	2	350	488	18	1.14	50	-	-	-	-	-	-	2	350	488	18	1.14	50
360	2	363	563	18	1.18	-	-	-	-	-	-	-	2	363	563	18	1.18	-
370	-	-	-	-	-	-	1	379	550	-	1.01	0	1	379	550	-	1.01	0
380	-	-	-	-	-	-	4	382	656	13	1.17	50	4	382	656	13	1.17	50
410	-	-	-	-	-	-	1	410	700	-	1.02	100	1	410	700	-	1.02	100
480	1	480	1050	-	0.95	100	-	-	-	-	-	-	1	480	1050	-	0.95	100
510	1	513	1550	-	1.15	100	-	-	-	-	-	-	1	513	1550	-	1.15	100
530	1	530	1600	-	1.07	100	-	-	-	-	-	-	1	530	1600	-	1.07	100
TOTAL	11						12						24					
MEAN		384	720	464	1.16			353	515	149	1.14			365	599	346	1.14	

Appendix 24. Biological data by age group for walleye caught by experimental gillnets (38mm mesh), Kakisa Lake, 1978.

AGE (YR)	MALES							FEMALES							COMBINED						
		LENGTH(MM)		WEIGHT(G)			%		LENGTH(MM)		WEIGHT(G)			%		LENGTH(MM)		WEIGHT(G)			%
	N	MEAN	SD	MEAN	SD	K	MAT	N	MEAN	SD	MEAN	SD	K	MAT	N	MEAN	SD	MEAN	SD	K	MAT
4	1	224	-	100	-	0.89	-	3	199	14.7	92	14	1.16	67	12	208	24.5	106	28	1.19	18
5	4	259	8.1	194	13	1.11	0	1	220	-	100	-	0.94	0	16	250	17.2	182	43	1.15	0
6	10	297	27.0	303	102	1.12	25	3	281	18.6	267	58	1.18	0	16	290	24.4	284	88	1.14	13
7	17	326	17.1	404	69	1.16	60	9	316	19.2	358	72	1.12	50	31	315	26.3	368	87	1.15	42
8	14	339	25.3	475	125	1.21	80	16	346	21.2	477	113	1.14	82	31	341	24.7	469	120	1.17	77
9	7	355	25.3	525	121	1.16	33	3	364	36.0	567	176	1.15	100	10	358	27.0	538	130	1.16	67
10	1	385	-	725	-	1.27	-	1	388	-	750	-	1.28	100	2	387	2.1	738	18	1.28	100
12	-	-	-	-	-	-	-	1	455	-	1050	-	1.11	100	1	455	-	1050	-	1.11	100
15	-	-	-	-	-	-	-	1	498	-	1400	-	1.13	100	1	498	-	1400	-	1.13	100
TOTAL	54							38							120						
MEAN		322	37	404	145	1.16			328	61.6	445	254	1.14			306	56.1	367	202	1.16	
MEAN AGE		7.6							7.6							6.9					

Appendix 25. Biological data by age group for walleye caught by experimental gillnets (64mm mesh), Kakisa Lake, 1978.

AGE (YR)	MALES							FEMALES							COMBINED						
	LENGTH(MM)			WEIGHT(G)			%	LENGTH(MM)			WEIGHT(G)			%	LENGTH(MM)			WEIGHT(G)			%
	N	MEAN	SD	MEAN	SD	K	MAT	N	MEAN	SD	MEAN	SD	K	MAT	N	MEAN	SD	MEAN	SD	K	MAT
4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	258	-	200	-	1.16	0
5	12	281	31.6	263	99	1.14	57	2	292	9.2	300	0	1.21	50	24	274	27.9	247	77	1.18	26
6	20	288	30.4	288	68	1.23	67	18	301	32.2	318	112	1.14	71	50	292	28.4	290	84	1.16	47
7	31	327	24.5	398	102	1.13	47	30	333	20.4	400	79	1.09	81	70	327	22.7	393	89	1.12	53
8	30	345	19.1	473	82	1.15	68	23	361	25.0	539	109	1.13	100	57	350	24.3	493	102	1.14	78
9	3	350	39.3	492	151	1.13	100	6	374	16.9	567	63	1.08	100	9	366	26.6	542	98	1.10	100
14	1	473	-	1200	-	1.13	100	-	-	-	-	-	-	-	1	473	-	1200	-	1.13	100
TOTAL	97							79							212						
MEAN		321	39	393	146	1.16			336	34.8	432	131	1.11			321	39.2	388	141	1.14	
MEAN AGE	7.2							7.2							6.9						

Appendix 26. Biological data by age group for walleye caught by experimental gillnets (89mm mesh), Kakisa Lake, 1978.

AGE (YR)	MALES							FEMALES							COMBINED						
	LENGTH(MM)			WEIGHT(G)			%	LENGTH(MM)			WEIGHT(G)			%	LENGTH(MM)			WEIGHT(G)			%
	N	MEAN	SD	MEAN	SD	K	MAT	N	MEAN	SD	MEAN	SD	K	MAT	N	MEAN	SD	MEAN	SD	K	MAT
6	1	262	-	200	-	1.11	100	-	-	-	-	-	-	-	1	262	-	200	-	1.11	100
7	13	342	23.3	490	107	1.20	75	2	352	11.3	500	0	1.15	100	15	343	22.1	492	99	1.20	78
8	26	361	17.6	550	70	1.16	54	25	362	17.0	558	72	1.17	91	52	361	17.9	550	75	1.16	68
9	15	379	16.2	625	71	1.14	100	13	383	20.1	646	87	1.15	100	30	379	20.2	627	85	1.15	90
10	3	388	3.6	617	29	1.06	100	5	385	24.7	645	76	1.14	100	8	386	18.9	634	61	1.11	100
11	3	413	19.4	808	170	1.14	100	1	387	-	700	-	1.21	100	4	406	20.4	781	149	1.16	100
12	5	452	20.4	950	155	1.02	100	-	-	-	-	-	-	-	5	452	20.4	950	155	1.02	100
13	1	457	-	950	-	1.00	100	-	-	-	-	-	-	-	1	457	-	950	-	1.00	100
TOTAL	67							46							116						
MEAN		372	37	600	163	1.15			371	21.1	593	88	1.16			370	32.0	594	138	1.15	
MEAN AGE	8.5							8.5							8.6						

Appendix 27. Biological data by age group for walleye caught by experimental gillnets (114mm mesh), Kakisa Lake, 1978.

AGE (YR)	MALES N	MALES LENGTH(MM) MEAN	MALES LENGTH(MM) SD	MALES WEIGHT(G) MEAN	MALES WEIGHT(G) SD	MALES K	MALES % MAT	FEMALES N	FEMALES LENGTH(MM) MEAN	FEMALES LENGTH(MM) SD	FEMALES WEIGHT(G) MEAN	FEMALES WEIGHT(G) SD	FEMALES K	FEMALES % MAT	COMBINED N	COMBINED LENGTH(MM) MEAN	COMBINED LENGTH(MM) SD	COMBINED WEIGHT(G) MEAN	COMBINED WEIGHT(G) SD	COMBINED K	COMBINED % MAT
6	-	-	-	-	-	-	-	2	292	4.9	263	18	1.06	-	2	292	4.9	263	18	1.06	-
7	2	311	16.3	375	35	1.25	0	4	339	21.7	450	61	1.16	100	6	329	23.4	425	63	1.19	33
8	10	352	28.4	498	125	1.13	17	3	350	12.0	483	63	1.12	-	13	351	25.1	494	111	1.13	17
9	1	360	-	475	-	1.02	-	1	385	-	700	-	1.23	100	2	373	17.7	588	159	1.12	100
10	-	-	-	-	-	-	-	1	423	-	900	-	1.19	100	1	423	-	900	-	1.19	100
11	-	-	-	-	-	-	-	1	446	-	1000	-	1.13	100	1	446	-	1000	-	1.13	100
12	1	415	-	900	-	1.26	100	2	451	12.7	975	35	1.06	100	3	439	22.6	950	50	1.13	100
13	1	480	-	1075	-	0.97	-	2	494	9.2	1313	53	1.09	100	3	489	10.1	1233	142	1.05	100
14	2	504	23.3	1263	53	0.99	100	2	513	26.9	1413	265	1.04	100	4	508	21.3	1338	179	1.02	100
15	1	487	-	1200	-	1.04	100	-	-	-	-	-	-	-	1	487	-	1200	-	1.04	100
16	4	477	14.9	1256	101	1.16	100	2	541	32.5	1600	106	1.02	100	6	498	38.1	1371	200	1.11	100
TOTAL	22							20							42						
MEAN		400	72	769	381	1.12			412	85.2	849	465	1.10			405	77.8	807	419	1.11	
MEAN AGE	10.2							10.2							10.5						

Appendix 28. Biological data by age group for walleye caught by experimental gillnets (139mm mesh), Kakisa Lake, 1978.

AGE (YR)	MALES N	MALES LENGTH(MM) MEAN	MALES LENGTH(MM) SD	MALES WEIGHT(G) MEAN	MALES WEIGHT(G) SD	MALES K	MALES % MAT	FEMALES N	FEMALES LENGTH(MM) MEAN	FEMALES LENGTH(MM) SD	FEMALES WEIGHT(G) MEAN	FEMALES WEIGHT(G) SD	FEMALES K	FEMALES % MAT	COMBINED N	COMBINED LENGTH(MM) MEAN	COMBINED LENGTH(MM) SD	COMBINED WEIGHT(G) MEAN	COMBINED WEIGHT(G) SD	COMBINED K	COMBINED % MAT
7	-	-	-	-	-	-	-	2	310	9.2	350	71	1.17	-	3	304	11.1	325	66	1.14	-
8	1	350	-	475	-	1.11	100	1	338	-	450	-	1.17	-	2	344	8.5	463	18	1.14	100
9	1	360	-	550	-	1.18	-	1	383	-	650	-	1.16	100	2	372	16.3	600	71	1.17	100
16	1	530	-	1600	-	1.07	100	-	-	-	-	-	-	-	1	530	-	1600	-	1.07	100
TOTAL	3							4							8						
MEAN		413	101	875	629	1.12			335	35.1	450	147	1.17			359	75.2	588	427	1.14	
MEAN AGE	7.8							7.8							8.9						

Appendix 29. Percent occurrence of various food types found in the stomachs of walleye examined from Kakisa Lake, 1978.

Number Fish	Number Fish Feeding	Percent Feeding	Food Type							
			Fish Remains		Benthic Invertebrates		Zooplankton		Unidentified Remains	
			No.	%	No.	%	No.	%	No.	%
1391	255	18.3	68	26.7	57	22.4	31	12.2	99	38.8

Appendix 30. Biological data by length interval for lake whitefish caught by experimental gillnets, Kakisa Lake, 1978.

LENGTH INTERVAL (MM)	MALES						FEMALES						COMBINED					
		LENGTH(MM)	WEIGHT(G)			%		LENGTH(MM)	WEIGHT(G)			%		LENGTH(MM)	WEIGHT(G)			%
	N	MEAN	MEAN	SD	K	MAT	N	MEAN	MEAN	SD	K	MAT	N	MEAN	MEAN	SD	K	MAT
200	-	-	-	-	-	-	-	-	-	-	-	-	1	201	100	-	1.23	0
210	-	-	-	-	-	-	-	-	-	-	-	-	1	215	200	-	2.01	0
230	-	-	-	-	-	-	-	-	-	-	-	-	1	234	150	-	1.17	0
240	-	-	-	-	-	-	-	-	-	-	-	-	3	244	200	0	1.38	0
250	1	250	200	-	1.28	-	-	-	-	-	-	-	1	250	200	-	1.28	-
260	-	-	-	-	-	-	1	262	200	-	1.11	-	1	262	200	-	1.11	-
270	2	272	325	35	1.62	0	-	-	-	-	-	-	3	271	300	50	1.50	0
280	-	-	-	-	-	-	1	280	325	-	1.48	100	2	280	313	18	1.42	100
290	1	293	350	-	1.39	-	1	295	300	-	1.17	-	2	294	325	35	1.28	-
300	1	306	350	-	1.22	0	1	307	400	-	1.38	-	3	306	383	29	1.34	0
310	2	316	425	35	1.35	-	2	312	450	71	1.49	100	6	314	425	45	1.38	33
330	4	336	544	43	1.44	100	4	334	538	32	1.44	100	8	335	541	35	1.44	100
340	1	345	575	-	1.40	0	4	344	590	76	1.45	100	5	344	587	66	1.44	75
350	3	354	617	14	1.39	100	2	354	600	35	1.36	100	7	353	607	35	1.38	83
360	1	360	725	-	1.55	-	1	367	700	-	1.42	100	2	364	713	18	1.49	100
370	1	371	750	-	1.47	-	1	372	750	-	1.46	100	2	372	750	0	1.46	100
380	2	384	763	88	1.35	100	3	383	800	50	1.43	100	5	383	785	60	1.40	100
400	-	-	-	-	-	-	2	405	975	35	1.47	100	2	405	975	35	1.47	100
410	-	-	-	-	-	-	2	417	863	88	1.19	100	2	417	863	88	1.19	100
420	-	-	-	-	-	-	3	423	1033	176	1.36	100	3	423	1033	176	1.36	100
470	1	474	1200	-	1.13	100	-	-	-	-	-	-	1	474	1200	-	1.13	100
TOTAL	20						28						61					
MEAN		337	560	223	1.40			357	659	241	1.39			333	552	256	1.39	

Appendix 31. Biological data by length interval for northern pike caught by experimental gillnets, Kakisa Lake, 1978.

LENGTH INTERVAL (MM)	MALES						FEMALES						COMBINED					
		LENGTH(MM)	WEIGHT(G)			%		LENGTH(MM)	WEIGHT(G)			%		LENGTH(MM)	WEIGHT(G)			%
	N	MEAN	MEAN	SD	K	MAT	N	MEAN	MEAN	SD	K	MAT	N	MEAN	MEAN	SD	K	MAT
220	-	-	-	-	-	-	-	-	-	-	-	-	1	228	100	-	0.84	0
260	-	-	-	-	-	-	1	272	150	-	0.75	-	2	272	150	0	0.75	0
300	-	-	-	-	-	-	1	303	200	-	0.72	0	1	303	200	-	0.72	0
340	1	345	290	-	0.71	0	1	352	300	-	0.69	100	2	349	295	7	0.70	50
360	2	368	350	0	0.71	0	-	-	-	-	-	-	3	369	350	0	0.70	0
380	3	387	400	0	0.69	0	4	393	519	191	0.85	100	7	390	468	149	0.78	33
400	2	408	463	18	0.68	0	2	401	700	354	1.09	-	5	404	555	221	0.84	0
440	2	445	600	71	0.68	0	2	449	663	18	0.73	100	4	447	631	55	0.71	50
460	3	469	725	75	0.70	0	5	464	690	89	0.69	100	8	466	703	81	0.69	60
480	2	488	900	0	0.77	100	3	491	800	50	0.68	100	6	491	858	74	0.73	100
500	2	507	838	53	0.64	-	5	508	905	148	0.69	100	8	508	903	128	0.69	100
520	5	525	980	119	0.68	100	2	530	1100	318	0.74	50	9	525	986	160	0.68	67
540	3	542	942	181	0.59	100	2	549	1100	141	0.67	100	8	546	1022	133	0.63	80
560	6	569	1192	113	0.65	80	9	569	1247	241	0.67	100	16	569	1225	190	0.66	93
580	6	588	1367	208	0.67	100	3	588	1333	231	0.65	100	11	588	1341	184	0.66	100
600	3	608	1575	139	0.70	100	4	605	1319	114	0.60	100	9	608	1439	208	0.64	100
620	4	631	1563	522	0.62	100	-	-	-	-	-	-	4	631	1563	522	0.62	100
640	1	650	1925	-	0.70	100	1	644	1725	-	0.65	100	2	647	1825	141	0.67	100
660	-	-	-	-	-	-	2	675	2388	88	0.78	100	2	675	2388	88	0.78	100
680	-	-	-	-	-	-	2	689	2025	318	0.62	100	2	689	2025	318	0.62	100
700	1	710	2925	-	0.82	100	1	705	2575	-	0.73	100	2	708	2750	247	0.78	100
780	-	-	-	-	-	-	1	780	3725	-	0.78	100	2	783	3550	247	0.74	100
TOTAL	46						51						114					
MEAN		527	1062	529	0.67			526	1129	662	0.71			525	1092	619	0.69	

Appendix 32. Biological data by length interval for least cisco caught by experimental gillnets, Kakisa Lake, 1978.

LENGTH INTERVAL (MM)	MALES						FEMALES						COMBINED					
		LENGTH(MM)	WEIGHT(G)			%		LENGTH(MM)	WEIGHT(G)			%		LENGTH(MM)	WEIGHT(G)			%
	N	MEAN	MEAN	SD	K	MAT	N	MEAN	MEAN	SD	K	MAT	N	MEAN	MEAN	SD	K	MAT
150	3	158	50	0	1.28	100	5	154	50	0	1.38	100	9	155	50	0	1.35	100
160	-	-	-	-	-	-	10	164	50	0	1.13	100	10	164	50	0	1.13	100
170	1	174	50	-	0.95	100	8	172	56	12	1.11	100	9	172	56	11	1.09	100
180	-	-	-	-	-	-	1	180	50	-	0.86	100	1	180	50	-	0.86	100
TOTAL	4						24						29					
MEAN		162	50	0	1.19			165	52	7	1.16			164	52	6	1.17	

Appendix 33. Biological data by length interval for longnose sucker caught by experimental gillnets, Kakisa Lake, 1978.

LENGTH INTERVAL (MM)	MALES N	MALES LENGTH(MM) MEAN	MALES WEIGHT(G) MEAN	MALES WEIGHT(G) SD	MALES K	MALES % MAT	FEMALES N	FEMALES LENGTH(MM) MEAN	FEMALES WEIGHT(G) MEAN	FEMALES WEIGHT(G) SD	FEMALES K	FEMALES % MAT	COMBINED N	COMBINED LENGTH(MM) MEAN	COMBINED WEIGHT(G) MEAN	COMBINED WEIGHT(G) SD	COMBINED K	COMBINED % MAT
170	-	-	-	-	-	-	-	-	-	-	-	-	1	170	50	-	1.02	0
180	-	-	-	-	-	-	-	-	-	-	-	-	1	188	75	-	1.13	0
190	-	-	-	-	-	-	-	-	-	-	-	-	1	194	100	-	1.37	0
300	-	-	-	-	-	-	-	-	-	-	-	-	1	300	300	-	1.11	0
320	1	320	600	-	1.83	100	-	-	-	-	-	-	1	320	600	-	1.83	100
370	1	372	775	-	1.51	-	-	-	-	-	-	-	1	372	775	-	1.51	-
380	1	380	800	-	1.46	100	-	-	-	-	-	-	1	380	800	-	1.46	100
390	-	-	-	-	-	-	1	398	850	-	1.35	100	1	398	850	-	1.35	100
420	-	-	-	-	-	-	1	422	1150	-	1.53	100	1	422	1150	-	1.53	100
460	-	-	-	-	-	-	1	462	1300	-	1.32	100	1	462	1300	-	1.32	100
TOTAL	3						3						10					
MEAN		357	725	109	1.60			427	1100	229	1.40			321	600	453	1.36	

Appendix 34. Biological data by length interval for white sucker caught by experimental gillnets, Kakisa Lake, 1978.

LENGTH INTERVAL (MM)	MALES N	MALES LENGTH(MM) MEAN	MALES WEIGHT(G) MEAN	MALES WEIGHT(G) SD	MALES K	MALES % MAT	FEMALES N	FEMALES LENGTH(MM) MEAN	FEMALES WEIGHT(G) MEAN	FEMALES WEIGHT(G) SD	FEMALES K	FEMALES % MAT	COMBINED N	COMBINED LENGTH(MM) MEAN	COMBINED WEIGHT(G) MEAN	COMBINED WEIGHT(G) SD	COMBINED K	COMBINED % MAT
180	1	182	75	-	1.24	0	-	-	-	-	-	-	2	184	88	18	1.41	0
210	-	-	-	-	-	-	-	-	-	-	-	-	1	215	150	-	1.51	-
270	1	274	300	-	1.46	-	-	-	-	-	-	-	1	274	300	-	1.46	-
300	-	-	-	-	-	-	-	-	-	-	-	-	1	300	350	-	1.30	0
340	-	-	-	-	-	-	1	344	650	-	1.60	100	1	344	650	-	1.60	100
360	3	362	600	173	1.27	100	-	-	-	-	-	-	3	362	600	173	1.27	100
370	5	376	810	42	1.52	100	-	-	-	-	-	-	5	376	810	42	1.52	100
380	1	384	775	-	1.37	100	1	384	825	-	1.46	100	2	384	800	35	1.41	100
390	-	-	-	-	-	-	2	394	988	53	1.61	100	2	394	988	53	1.61	100
400	1	400	925	-	1.45	100	3	404	983	52	1.49	100	4	403	969	52	1.48	100
410	1	418	1200	-	1.64	100	2	418	1000	0	1.37	100	3	418	1067	115	1.46	100
420	-	-	-	-	-	-	4	423	1150	58	1.52	100	5	424	1150	50	1.51	100
430	1	433	1050	-	1.29	100	1	430	1150	-	1.45	100	2	432	1100	71	1.37	100
440	-	-	-	-	-	-	3	447	1292	14	1.45	100	4	445	1250	84	1.41	100
450	-	-	-	-	-	-	2	457	1438	88	1.51	100	2	457	1438	88	1.51	100
460	-	-	-	-	-	-	2	465	1450	141	1.44	100	2	465	1450	141	1.44	100
500	-	-	-	-	-	-	1	500	1925	-	1.54	100	1	500	1925	-	1.54	100
TOTAL	14						22						41					
MEAN		361	727	294	1.42			426	1169	274	1.49			390	946	395	1.46	

Appendix 35. Biological data by age group for lake whitefish caught in experimental gillnets, Kakisa Lake, 1978.

AGE (YR)	MALES N	MALES LENGTH(MM) MEAN	MALES LENGTH(MM) SD	MALES WEIGHT(G) MEAN	MALES WEIGHT(G) SD	MALES K	MALES % MAT	FEMALES N	FEMALES LENGTH(MM) MEAN	FEMALES LENGTH(MM) SD	FEMALES WEIGHT(G) MEAN	FEMALES WEIGHT(G) SD	FEMALES K	FEMALES % MAT	COMBINED N	COMBINED LENGTH(MM) MEAN	COMBINED LENGTH(MM) SD	COMBINED WEIGHT(G) MEAN	COMBINED WEIGHT(G) SD	COMBINED K	COMBINED % MAT
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	240	-	200	-	1.45	-
4	1	250	-	200	-	1.28	-	-	-	-	-	-	-	-	4	233	22.0	163	48	1.26	0
5	-	-	-	-	-	-	-	2	335	7.1	500	0	1.33	100	7	288	46.2	354	134	1.44	20
6	2	327	16.3	500	141	1.42	100	4	322	40.1	509	213	1.42	100	8	317	31.0	464	170	1.39	80
7	6	318	32.2	454	137	1.38	25	3	313	20.2	458	142	1.46	100	10	320	28.0	475	137	1.42	33
8	5	344	25.2	590	146	1.43	100	6	357	40.0	671	235	1.41	100	11	351	33.2	634	195	1.42	100
9	2	366	7.8	738	18	1.51	-	5	379	28.7	795	237	1.42	100	8	373	24.3	750	199	1.42	100
10	2	371	19.1	650	71	1.28	100	2	386	48.1	713	194	1.23	100	4	378	31.2	681	125	1.26	100
11	-	-	-	-	-	-	-	1	425	-	1050	-	1.37	100	1	425	-	1050	-	1.37	100
TOTAL	18							23							54						
MEAN		333	36	536	169	1.40			354	42.4	647	236	1.40			328	52.2	528	237	1.39	
MEAN AGE		7.8							7.8							7.1					

Appendix 36. Biological data by age group for northern pike caught in experimental gillnets, Kakisa Lake, 1978.

AGE (YR)	MALES N	MALES LENGTH(MM) MEAN	MALES LENGTH(MM) SD	MALES WEIGHT(G) MEAN	MALES WEIGHT(G) SD	MALES K	MALES % MAT	FEMALES N	FEMALES LENGTH(MM) MEAN	FEMALES LENGTH(MM) SD	FEMALES WEIGHT(G) MEAN	FEMALES WEIGHT(G) SD	FEMALES K	FEMALES % MAT	COMBINED N	COMBINED LENGTH(MM) MEAN	COMBINED LENGTH(MM) SD	COMBINED WEIGHT(G) MEAN	COMBINED WEIGHT(G) SD	COMBINED K	COMBINED % MAT
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	250	31.1	125	35	0.79	0
2	1	508	-	875	-	0.67	-	3	322	61.2	275	175	0.76	0	4	368	106	425	332	0.73	0
3	10	430	54.1	567	211	0.68	0	6	434	44.3	667	236	0.82	100	19	437	64.4	643	341	0.73	13
4	10	470	73.4	775	329	0.71	50	17	502	66.7	904	384	0.68	93	29	493	68.2	864	352	0.69	81
5	10	580	39.4	1318	320	0.67	100	11	561	44.4	1177	213	0.66	100	23	566	43.3	1221	270	0.67	95
6	6	588	33.6	1354	464	0.65	83	7	598	72.5	1510	645	0.67	100	19	598	67.2	1464	663	0.65	85
7	6	606	65.6	1583	772	0.68	100	1	705	-	2575	-	0.73	100	8	606	76.1	1638	779	0.70	100
8	-	-	-	-	-	-	-	2	730	71.4	3025	990	0.76	100	3	676	105	2425	1253	0.73	100
9	1	630	-	1250	-	0.50	100	1	698	-	1800	-	0.53	100	2	664	48.1	1525	389	0.51	100
TOTAL	44							48							109						
MEAN		525	89	1053	539	0.67			528	105.6	1128	680	0.70			524	103.3	1087	631	0.69	
MEAN AGE		4.6							4.6							4.7					

Appendix 37. Biological data by age group for least cisco caught in experimental gillnets, Kakisa Lake, 1978.

AGE (YR)	MALES							FEMALES							COMBINED						
	N	LENGTH(MM) MEAN	SD	WEIGHT(G) MEAN	SD	K	% MAT	N	LENGTH(MM) MEAN	SD	WEIGHT(G) MEAN	SD	K	% MAT	N	LENGTH(MM) MEAN	SD	WEIGHT(G) MEAN	SD	K	% MAT
3	-	-	-	-	-	-	-	2	169	2.1	63	18	1.30	100	2	169	2.1	63	18	1.30	100
4	1	174	-	50	-	0.95	100	10	163	8.5	50	0	1.18	100	11	164	8.8	50	0	1.16	100
5	-	-	-	-	-	-	-	2	173	9.9	50	0	0.98	100	2	173	9.9	50	0	0.98	100
TOTAL	1							14							15						
MEAN		174	-	50	-	0.95			165	8.6	52	7	1.17			166	8.6	52	6	1.15	
MEAN AGE	4.0							4.0							4.0						